THE GLASS INDUSTRY
THE JOURNAL OF GLASS MANUFACTURING

On the Threshold

an editorial

In this fast-moving world it is not wise to think too much in the past, although our industry does have a heritage of which glass men everywhere can be rightly proud.

Just two years ago, the world suddenly felt the awesome impact of the Space Age as the first man-made satellite was thrust into orbit. At that moment the words, *Technology*, *Research* and *Development*, assumed a new importance.

At that moment, too, glass, the ancient product, achieved a new prominence, as a high-temperature material in fiber glass nose cones; as an important factor in solar energy; and as a protection for men against nuclear radiation in "hot" areas.

Indeed, glass research is progressing in many directions. The all-glass automobile is on the drawing board; stronger and lighter glass containers are continually being developed; homes, schools and industrial buildings are now designed with single- and double-glass windows for controlling solar radiation, temperature and visibility; and many unexpected possibilities are appearing in electronics which take advantage of the properties of glass.

Although glass is on the threshold of a prosperous, new era, the industry is keenly aware of the constant challenge of competing materials. It behooves all of us to broadcast at large as often as possible the unique qualities inherent in this versatile product.

We, as a technical publication, have a most important role in this unfolding picture, for we must report on all of these dynamic areas in order to provide a continuous exchange of information, both theoretical and practical, always thinking first how best to serve the field of glass manufacture. We consider this a privilege and, as we stated in our first editorial in 1920, our major endeavor is to obtain and publish regularly, original papers, discussions and data on glass manufacturing.

In our 40th year we pause to review some of the accomplishments you have made, and to look at some of the areas of tomorrow's research that are so important to the creation of a better glass product.

As we stand on the threshold of the Space Age, we realize the serious and important nature of the task ahead; THE GLASS INDUSTRY will uphold its responsibility by continuing to be a leading source of glass manufacturing knowledge in this newest and most exciting era of all mankind.

Fig. 1

A cathetometer is used to read mercury level in dilatometer immersed in thermostating bath. The device is used for measuring thermal expansion of glass at and near room temperature.

GLASS RESEARCH at the National Bureau of Standards

by C. H. Hahner, CHIEF, GLASS SECTION, NATIONAL BUREAU OF STANDARDS

This article presents a general account of research and development in glass technology at the National Bureau of Standards. A brief history of the Bureau's activities in this area in past years is presented, followed by a more detailed account of the basic studies of the chemical, thermal, optical and mechanical properties of glass and glass-forming systems that are now in progress.

Fig. 2

Oscillating cup viscometer for use at high temperatures, possibly above 2000°C. Upper foreground—the vaccum chamber has been raised to show the induction heating coil surrounding the oscillating cup. Vacuum system and high frequency generator: lower foreground and background.

● GLASS RESEARCH at the National Bureau of Standards emphasizes the measurement of basic chemical and physical properties of glass and the investigation of glass-forming systems. As in other lines of technology, it is more profitable in the long run to attempt to find solutions to the basic problems of constitution and chemistry of the whole field than to find immediate answers to restricted problems.

When the Bureau was founded in 1901, it began a program of optical research and development that over the years has led to the solution of many problems of interest to government agencies and private industry. The Bureau's first interest in glass was mainly in its use as an optical material.

Work on methods of producing optical glass was first started shortly before this country entered World War I. Because of its importance in military instruments, a small plant was established by the Bureau to produce optical glass. One of the notable achievements of the very early work on optical glass was the development, under the direction of A. V. Bleininger, of a method of slip-casting a porcelain-type body to form the pots in which glass was melted. This process later largely supplanted the old process of hand forming glass-melting pots.

During World War II the Bureau's work on optical glass was greatly intensified. Large quantities of glass were produced and the number of types greatly increased. Little experimental work was necessary to produce some of these glasses, because information on their manufacture had already been published. In other cases entirely new types, on which little or no data had previously existed, were developed in the laboratory and put into full-scale production. Technical assistance was given to several manufacturers in the United States who were thus enabled to begin producing optical glass in a short time to meet emergency needs, although they had had no previous experience in optical glass manufacture. With the end of the war, the optical glass program at the Bureau returned to pilot-scale operations and to research on new compositions and methods of making glass. The production of optical glass at the Bureau was continually decreased and finally stopped in 1957, as it was apparent that commercial production was adequate to take care of military requirements.

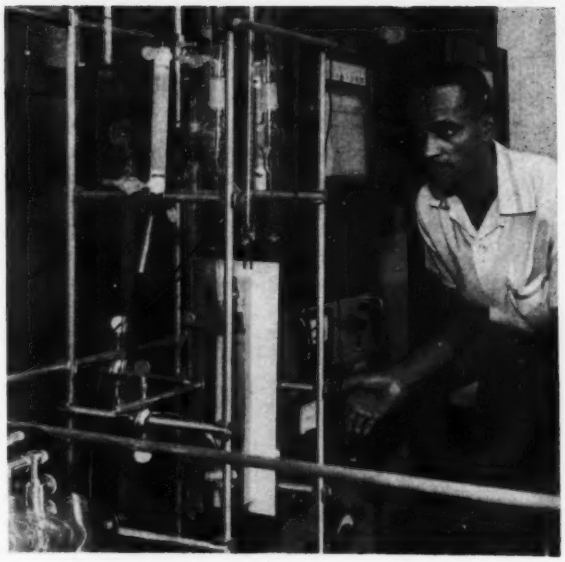


Fig. 3

Electrophoretic cell used in the study of the kinetics of the release of alkali from glass. The alkali released is determined by a coulometric method.

Present Work on Glass

The work of the Bureau's glass laboratories has changed greatly in the past few years. Emphasis is now on the measurement of those properties of glass that give promise of yielding information on the principles governing molecular structure in the glassy state. This problem is being approached by a number of different methods. The idea common to all is to obtain information which will add to our knowledge of the glassy state.

Of continuing interest are investigations of glasses not only at low temperatures, where they exist as rigid solids, but also at elevated temperatures where they exist as mobile liquids. Glass properties, at the lower temperatures, depend not only on chemical composition, but also on the thermal history.

Excess Entropy of Glass

One of the most common features of glasses is their greater molecular disorder in comparison with the corresponding crystals. This can be expressed quantitatively in terms of entropy. Efforts are underway to measure the excess entropy of the glassy state in two ways. These measurements must, of course, be made on glasses for which stoichiometrically corresponding crystals also exist.

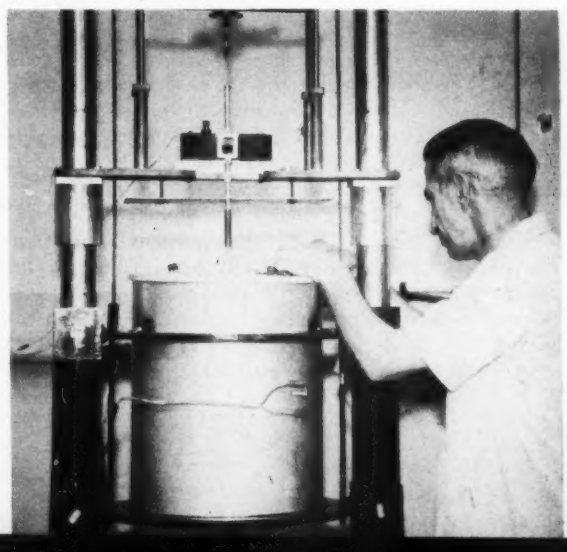
One method is by direct measurements of specific heats over the temperature range from the liquid just above the melting point of the crystal down to as near as possible to absolute zero. The entropies computed from these specific heats give a measure of the degree of molecular disorder in glass. A precision low-temperature adiabatic calorimeter for part of these measurements is nearing completion. It will be supplemented with a high temperature drop calorimeter. As an independent method, vapor pressures are being measured as a function of temperature for substances such as arsenic oxide in vitreous and crystalline states. The entropies of vaporization obtained therefrom give values for the excess entropy of the glass. Measurements of vapor pressure on vitreous arsenic trioxide have led to interesting side-results indicating an extremely low condensation coefficient.

Glass Transition Temperature

As a criterion for the transformation between the vitreous and the supercooled liquid states, investigations are being made of the precision with which a scientifically significant glass transition temperature can be operationally defined and determined. The super cooled liquid exists below the liquidus and above the temperature at which properties are dependent upon thermal history. The effect of rate of temperature change on the volume-temperature curve is being measured for experimentally convenient glasses such as nitrate mixtures, selenium and glucose, which have glass transformation temperatures in the vicinity of room temperature. Deliberate variations in heat treatment result in variations of transformation temperature of less than 6°C. Measurements of transformation temperature as a function of composition in

Fig. 4

Rotating cylinder viscometer used for measuring the viscosity of glass at temperatures up to 1450°C.



two component systems have suggested that some systems form glasses only at stoichiometric ratios of the compounds, and a greater number form glasses also at non-stoichiometric ratios.

Measured differences in thermal expansion coefficients for glass-forming substances above and below their glass transformation temperatures have been compared with values predicted theoretically from their viscosity-temperature relations. This has indicated that in most glasses, including silicates, the molecular structure may not change drastically with temperature in the transition region. In borate and nitrate glasses, however, the thermal expansion data does not conflict with the idea of structure changes.

Transport Phenomena

Of particular interest is the study of transport phenomena through vitreous silicates, as this gives important information on both the bulk structure of glass and the structure of the surface domains. Because many properties of glass are highly dependent upon the surface condition, this is an extremely interesting field of work that gives promise of yielding much information of both theoretical and practical value. Under study at the present time is the migration of mobile ions, such as alkali, through the glass under the influence of a concentration gradient created by subjecting a glass surface to water or other environments containing diffusion sinks for alkali. The experimental study of the diffusion kinetics is performed by a coulometric method which simultaneously determines the amount of alkali released and removes any corrosion products, to maintain a constant pH. The data obtained are compared with mobility data derived from electrical conductivity measurements and analyzed with respect to various theoretical diffusion models. Of further interest are the details of the exchange-mechanism in the above process, namely the form in which water constituents enter the structure of the glass. Methods are being developed not only to observe the kinetics of the net-diffusion process but also to obtain successive concentration profiles through the glass at various stages of the diffusion process.

Special Optical Glasses

The increasing use of infrared devices in the fields of target detection, fire control, missile guidance and aerial reconnaisance creates a demand for improved optical materials for their construction. The investigation of the size, shape, and location of the glass-forming areas in the phase diagrams of simple two- and three-component systems provides much basic data for the development of multi-component glasses having desirable properties. The physical and optical properties of the simple glasses can be correlated with composition to furnish clues to the atomic and molecular units composing the glass structure and their arrangement.

The effects of small amounts of water in the internal structure of glass have been largely neglected in the past. The presence of this water is strongly evident in the infrared spectra of practically all glasses. If glass is to serve as an infrared transmitting material at wavelengths beyond 2.75 μ means must be found to eliminate, or reduce, the water content. Work along these lines has been in progress for some time. Glasses have been made in silicate, germanate, calcium aluminate and tellurite systems, and many of their properties determined.

Base compositions from the BaO-TiO_2-SiO_2 system were used to develop multi-component glasses having good infrared transmittance, and refractive index values, n_D, in the range from 1.74 to 1.94. These glasses have deformation temperatures above 800°C and show no surface alteration when exposed at 80°C for 6 hours to buffered solutions of pH 2 to 12. Other alkaline-earth silicate glasses have been made with good infrared transmittance and refractive index values of n_D, from 1.61 to 1.75.

GeO_2 has been substituted directly for SiO_2 in many of the better silicate glasses to obtain transmittance to a longer wavelength. In general, it has been found that the substitution of GeO_2 for SiO_2 increases the refractive index by about 0.03 to 0.04, extends the transmittance to about 6 μ, and lowers the deformation temperature by about 50°C.

The calcium aluminate glasses are characterized by a rather deep absorption band at about 3 μ but they recover to a maximum transmittance near 4 μ and cut-off in 2 mm. thicknesses near 6 μ. These glasses are prone to attack by moist atmospheres, which produce a white opaque surface film. They also devitrify easily when heated to the appropriate temperature range. They must be fabricated by casting to the approximate size since they cannot be molded or worked in a flame.

In an effort to improve the surface durability of the calcium aluminate glasses it was found that a SiO_2 content of about 8 mole per cent increased their resistance to attack by moisture. This caused the transmittance to be reduced beyond about 5 μ due to a Si-O absorption band. Surface durability could be improved still more by treatment with HF. An irridescent surface film was produced which reduced the attack by moisture and also had anti-reflecting properties.

In general, glasses of the calcium aluminate type have n_D values of about 1.67 to 1.70, deformation temperatures in the vicinity of 750°C, coefficients of expansion of about 9 to 10 x 10^{-6} and rather high values of elastic constants.

TeO_2, by itself, evidently does not form a glass when cooled at an ordinary rate. However, with other oxides, such as PbO, BaO, Al_2O_3 and WO_3, compositions rich in TeO_2 can be melted and cooled without crystallization. The glasses melt at fairly low temperatures, 800° to 1000°C. They have high coefficients of thermal expansion and are rather sensitive to thermal shock. The deformation temperatures are from about 350° to 400°C. The refractive index values, n_D, are high, in the vicinity of 1.9 to 2.2. Some of the infrared transmittance curves are fairly good, although most of them have a rather broad and deep absorption band at about 3 to 3.25 μ. The limit of their transmittance in 2 mm. thickness to the long wave lengths is about 6 μ. The glasses devitrify fairly easily and we have not been able to cool melts larger than about 500 g as homogeneous glasses free from crystalline material.

Recently we have found that the water band absorption is greatly reduced by the use of fluorides as an ingredient

(*Continued on page* 650)

COLOR ON GLASS

MOST GLASS ENAMELS are a two-component system composed of a clear, colorless flux and a coloring oxide or pigment.

Fluxes are made by mixing and melting together lead oxide, boric oxide, and silica, plus lesser amounts of soda, titanium dioxide, zirconium oxide and cadmium oxide. Titanium dioxide helps to improve acid resistance, and zirconium oxide aids alkali resistance.

During the process of manufacture, as the flux is melted, a thin stream is allowed to run into water which breaks it up into a size suitable for grinding. This process is usually referred to as watercracking or waterquenching. Typical examples of an acid and alkali resisting flux, and a non-resisting flux, are:

	Resistant Flux	Non-Resistant Flux
Lead Oxide	48.6	66.6
Boric Oxide	6.9	18.3
Silicon Dioxide	25.0	14.8
Cadmium Oxide	3.6	
Sodium Oxide	3.2	
Titanium Dioxide	2.4	
Zirconium Dioxide	6.7	
Sodium Silica Fluoride	3.6	

The flux serves as a permanent vehicle for the coloring pigments which are added as a mill addition, and it governs, to a large extent, melting temperature, coefficient of expansion, chemical durability and the stability of the resulting glass enamel.

Coloring pigments are usually made by mixing together and calcining at temperatures ranging between 1600°F. and 2400°F. various metallic oxides—or salts of these oxides which will, on heating, yield the oxide.

The one exception to this is bright red which is made by mixing and calcining, at about 1200°F., cadmium sulphide and selenium. Reds can also be made by a wet-chemical process.

Some typical examples of how coloring pigments are made include:

Bright blue. By calcining a mixture of cobalt oxide and aluminum oxide.

A very good black. By calcining together a mixture consisting of equal parts of the oxides of cobalt, iron and chromium.

Yellow. From antimony, tin, and lead oxides.

Blue-green pigments. Usually from calcined mixtures of chromium, cobalt, aluminum, and zinc oxides.

The watercracked flux, along with a suitable quantity of coloring pigment, is charged into a ball mill and waterground until it will pass a 325 mesh screen. This ground and dried product is a finished glass enamel.

Chemical Durability

From the standpoint of chemical durability glass enamels can be divided into two general categories.

1. Resistant enamels: Have some degree of resistance to attack by acid and alkalis.
2. Non-resistant enamels: Have very poor resistance to the solvent action of various acid and alkaline materials.

Prior to 1935 resistant-type enamels were unknown. It was at about this time, however, that a demand arose for glass enamels which could be used for decorating such items as dinnerware and multiple-trip beverage bottles—where resistance to attack by food acids and alkaline detergents was important. Development work was continued and, by 1940 enamels were available which would resist most types of chemical attack very well.

Demand has steadily increased since that time; today more than 90 per cent of the enamels sold are of the resistant type. In the dinnerware field the colors must resist the action of acids like acetic, citric, phosphoric and oxalic—and the strong alkaline detergents, which are widely used today in automatic dishwashers.

Another class of materials, which attack lead-containing glass enamels, are sulphides. These are found in a number of cosmetic preparations, and in many foods such as eggs and cabbage. Sulphides also appear in the atmosphere in areas where soft coal is being burned or where sulphur-bearing crude oils are being refined. They are a constituent of human perspiration. When sulphides attack a glass enamel they leave a brown or black metallic iridescence, removable either by refiring or by immersion in an oxidizing solution like hydrogen peroxide or sodium hypochlorite. The sulphides in food readily stain the glass enamels at the elevated temperatures at which they are served.

When multiple-trip beverage bottles are to be decorated, the primary consideration is alkali resistance, although in recent years a demand has developed for bottle enamels which not only resist the action of alkaline detergents, but also that of hydrochloric acid in which bottles are frequently washed in order to remove iron stains picked up from their metal closures. And some carbonated beverages contain very small quantities of phosphoric acid. (*Continued on page 648*)

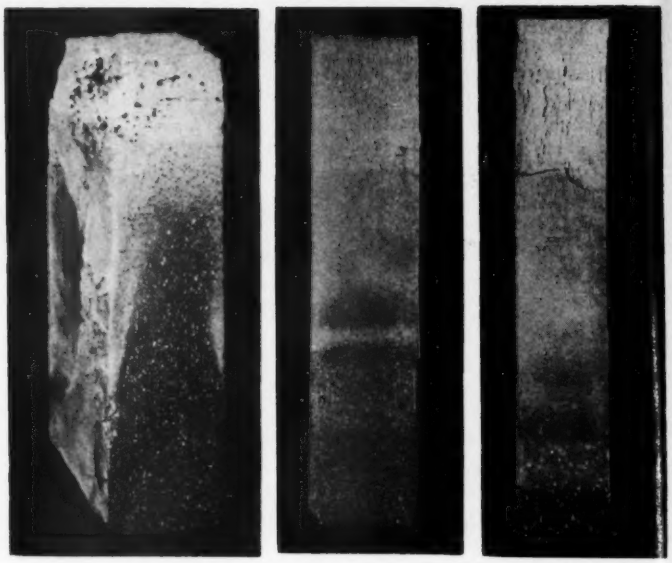


Fig. 1. Silica brick from a glass furnace crown, subjected to moderate boring conditions. Alkali condensation is concentrated near hot face. (Top of photograph.)

Fig. 2. Silica brick from an un-insulated glass furnace crown, showing zones of condensation, the highest zone being a semi-vitrified area representing the center third of the brick.

Fig. 3. Silica brick from an insulated glass furnace crown. Much of the alkali has migrated to the insulation beyond the cold face of the crown brick.

RESEARCH AND GLASS FURNACE REFRACTORIES

by Raymond E. Birch and Lee A. Kleeman

HARBISON-WALKER REFRACTORIES CO., PITTSBURGH, PA.

● THE GLASS INDUSTRY CONTINUES to make increasing demands on all refractory materials, with process modifications which require new and accelerated research techniques in order to evaluate properly, on the laboratory level, the suitability of various refractory materials for diversified applications in glass furnaces.

Through the use of new types of refractories and an impressive evolution of furnace engineering, glass furnace campaigns have increased by several hundred per cent within the last several decades. When furnaces were operated for a much shorter period of time, it was not a difficult matter to study the condition of various refractory materials at the end of a campaign, make replacements as necessary, up-grading as required, and

Fig. 4.
Various types of basic brick after oxidation-reduction test of 700 cycles at 2200° F.

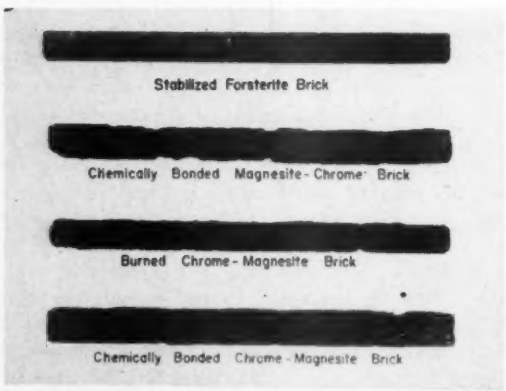
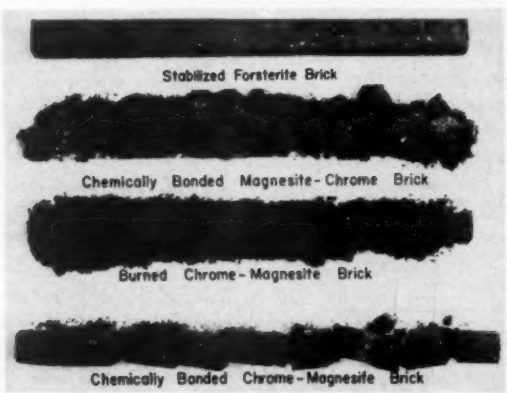


Fig. 5.
Various basic brick after oxidation-reduction test of 700 cycles at 2200° F. Subjected to pressure between thumb and fingers.



then restudy the furnace, perhaps after a lapse of as little as six months.

The furnace, in effect, was a laboratory in itself, and since there is no better way of evaluating refractory materials than by actual service trials, and since the period of time required for obtaining service data was not long, it was neither necessary nor practical to conduct simulated service tests in the laboratory. The "in-service" data were obtained much quicker than any laboratory data and were, after all, the *end* result.

Today, however, under severe operating conditions, campaigns of one to two years are common; many glass furnace operators think of a furnace campaign in terms of three to four years, and some operators are even realizing five-year campaigns with only minor hot repairs. These changing conditions, increasing severity of service conditions and extended campaigns, have developed a necessity for extensive laboratory "pre-testing" or evaluation of refractories prior to service trials. Continued progress in this field has made the extended campaigns and higher production rates possible.

If we might visualize a research laboratory as a tree, we would then think of the mineralogical division of such laboratory as the trunk. Mineralogical studies with the microscope and the x-ray have become one of the most important tools in studying refractory materials, unused, and predicting how they will meet the rigid requirements of glass furnace campaigns. Such studies of used specimens after a glass furnace campaign also show what reactions have taken place, and pave the way for prescribing an alteration in the refractory composition which results in lessening "in-service" alterations.

Since the waiting period for observing these changes in service has become so extended, methods of simulating service conditions in the laboratory have been, and are continuing to be, devised.

In the superstructure of the continuous melting furnace itself, silica refractories have proved themselves adequate, and the quality of silica refractories has kept pace with the glass industry's needs. However, the continually increasing production rates and higher temperatures have, in some instances, reached the limits of silica refractories, and other materials must now be found for supplementing or complementing them in the glass furnace superstructure.

Early mineralogical studies of silica brick taken from glass furnace superstructures revealed the high condensation of glass batch volatiles near the hot face of the refractory which ultimately resulted in a sufficient lowering of the refractoriness to cause the formation of a liquid or glassy phase in the interior of the brick, which, it is theorized, later drained through the joints. The result, called "boring", is particularly noted (Fig. 1) in tank crowns.

A means was found of equalizing the temperature gradient throughout the silica refractory, distributing the condensation, and in some cases, even moving it outside the furnace structure. This was accomplished by the development of a silica insulating brick which is compatible with the silica superstructure. This was a primary step in continuing efforts to extend furnace crown life (Figs. 2 and 3).

Just as basic refractories have enabled other industries to increase operating temperatures and production rates, basic refractories might well be the answer to the increasing demands of the glass furnace operator.

Small scale trials of basic refractories in the breast-walls and other vulnerable spots of sodium silicate tanks indicate their high resistance to reaction with glass batch constituents. The only reason for hesitancy in the use of basic refractories in the superstructure of glass producing tanks lies in the possibility of contamination of the glass batch from basic refractory materials. However, it is believed that high purity basic refractories offer a promising range of compositions which may ultimately qualify for these services. Work on these materials is progressing on the laboratory level.

It has long been known that basic refractories have a considerable degree of immunity to the volatile components of most glass batches. For this reason, they were a natural selection several years ago for glass furnace checkers and regenerator superstructure construction. However, the basic refractories initially used had relatively low resistance to other conditions which existed in the glass furnace, such as regenerative cycling. Most early basic refractories were high in unstabilized iron oxide and were disintegrated due to temperature as well as atmospheric oxidation-reduction cycles which are common in the glass furnace regenerator.

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Fig. 6.
View of basic regenerator uptake at end of a campaign. Brick in peephole protrude to original wall thickness.

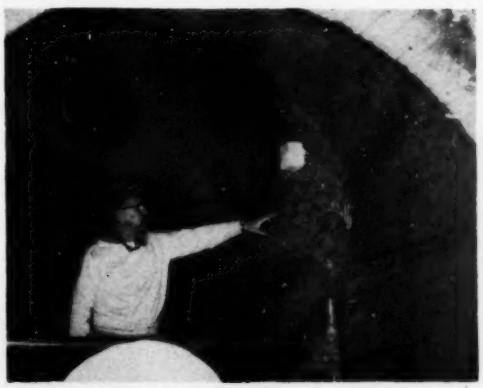

Fig. 7.
Same view as Fig. 6, showing restoration of regenerator contour by gunniting.

GLASS in the Nuclear Age

by A. V. Malizzewski

KNOLLS ATOMIC POWER LABORATORY, SCHENECTADY, N. Y.

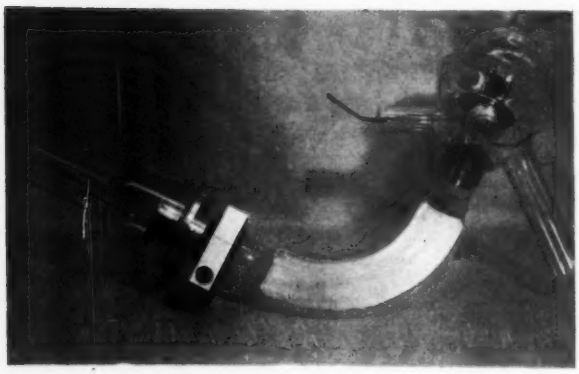

Fig. 1

Analyzer tube for a mass spectrometer, made by KAPL glass technicians. Unit is 2-3" in diameter at elbow, approximately two feet across at widest points.

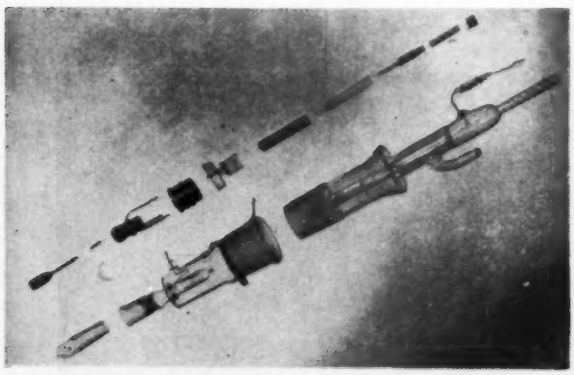

Fig. 2

A "sputterer," product of the KAPL glass shop, for etching minute layers of cladding from radioactive samples.

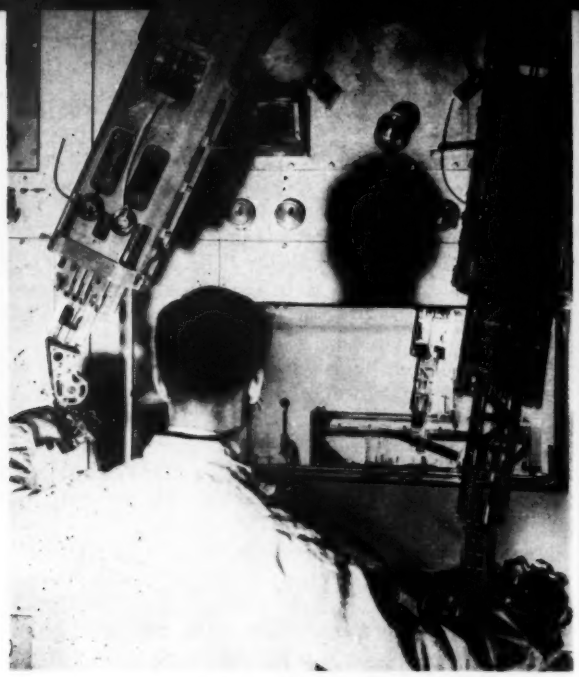

Fig. 3

Operator using a manipulator to position materials and equipment in a "hot" cell.

From transparent models used in developing efficient cooling systems to major components of highly specialized instruments, glass, because of its versatility, plays an important part in nuclear development. In this article, a glass expert at an outstanding nuclear laboratory tells how glass is used in the advancement of this new science.

● At the Knolls Atomic Power Laboratory*, one of the oldest and largest nuclear development laboratories in the country, special glassware and glass technicians are making major contributions to the development of nuclear power systems for such naval vessels as the *Triton* (Fig. 7), largest submarine in the world, and the U.S.S. Bainbridge, world's first nuclear-powered destroyer. The former vessel was launched last year and is now undergoing sea trials. Development of the Bainbridge's power plant is a current laboratory project.

Fig. 4

Glass model of a marine nuclear power plant mounted in a frame that can be rocked in any direction to simulate motion of a ship's hull.

Although KAPL is a laboratory in the highest scientific tradition, the *development*, rather than *research*, nature of its activities gives the work a distinctive character. The glassware fabricated there reflects this difference, for about half of the glasswork is of the type usually specified for engineering development rather than chemical research (Fig. 6).

This means the production of pieces and assemblies with such characteristics as the ability to withstand internal pressures of 50 psi; satisfying tolerance requirements in the ranges of ±0.001″ to ±0.0005″, when tolerances of ±1/8″ are normal for most dimensions of fabricated laboratory ware; machining threads into glass rod, a procedure successfully performed by adapting to the glass rod the thread-grinding technique used with unusually hard and brittle metals; fusing various glasses to all types of metals and ceramics, such as cold-rolled steel, porcelain and high alumina ceramic; and insulating the terminal end of small diameter stainless sheathed thermocouple wire by using molten glass.

Through the growth of specialized knowledge, these operations can be performed successfully today, although they were considered impractical at first because of cost considerations and the types of materials involved.

Furthermore, another distinction is that design requirements often specify that the glassware be constructed so as to provide maximum ease of assembly and disassembly by remote control through utilization of mechanical manipulators (Fig. 3). These devices simulate most of the actions of the human hand at long range, usually in areas where people cannot conveniently or safely enter. They are often used in radioactive areas or "cells" to position equipment or materials.

Various laboratory analytical processes performed under normal laboratory conditions must also be duplicated in these highly radioactive areas by means of manipulators. Glass components used in these experiments are frequently dropped and are extremely difficult to pick up again with the manipulators. Consequently, several sets of glass replacement components are conveniently located in a storage rack within the radioactive cubicle where the experiment is being carried out, thus making it easier to replace broken or inaccessible parts.

Today, the manipulators used by "hot lab" personnel have been perfected to the point where practically every movement of the human hand can be duplicated. Pressure sensitivity of the manipulators has also been improved to a great degree, and glass components are seldom fractured because of excessive pressure exerted by the manipulator tongs. The mechanical manipulator, however, cannot duplicate every movement of its human counterpart. The "arm" portion of the manipulator is, of necessity, bulkier and less flexible, and the manipulator tongs usually consist of two or three opposably mounted fingers. These limitations require special consideration when fabricating glassware that will be operated by remote control.

Glassware used in such applications must be designed to permit ease of handling, with easily grasped handles, definite pouring lips, and strong sides at point of contact.

Also, since there is a frequent necessity for replacement

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* Operated for the Atomic Energy Commission by the General Electric Company.

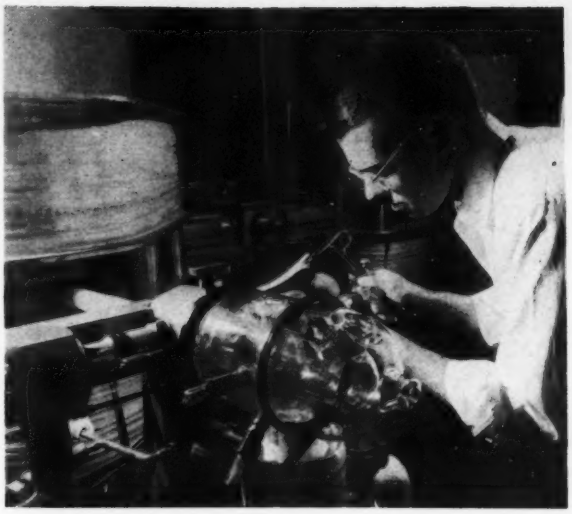


Fig. 5

Glass technician at the Knolls Atomic Power Laboratory repairing a break in a mass spectrometer's electron source.

Fig. 6

Shaping a special expansion chamber for high vacuum system on a lathe.

Fig. 7

Triton, World's largest submarine, being launched at Groton, Connecticut. Now undergoing sea trials, her two-reactor nuclear propulsion system was developed at KAPL.

Fig. 1. 16th Century woodcut illustration depicting glass manufacturing establishment.

GLASS MOLDS

Fig. 2. Early glassblowing. Young boys operated levers that held and released hand-made molds.

Fig. 3. Flasks of molding sand, ready to receive molten metal.

● THROUGHOUT THE GLASS INDUSTRY, continuing research results in new procedures, improved glass products, and a constant flow of multi-sized containers to fill the ever-growing demands and needs of the world.

Throughout the world, the consuming public enjoys the convenience and the protection of attractively designed glass packaging in a multitude of sizes and shapes.

And the basis for the shape of things in glass . . . is the precision-made mold.

A long history of discovery, invention, research, improvement and perfection has resulted in the highly developed glass industry of today. Glass molds have followed a similar pattern of progress.

Because of the lack of factual information or authoritative evidence, the technique of glass molding prior to the first century B. C. is largely a matter of supposition and "probable" deduction. Some sources, however, have described glass molding as far back as 1500 B. C., when Egyptians formed glass around a core of sand, and scraped the core away after the glass had set and cooled.

Some time during the first century B. C., the invention of the blow-pipe transformed glassmaking, and paved

the way for a widely expanded industry. Roman glassmakers at this time used many techniques of manufacture, including not only free-blown glass, but also that blown into hand-made molds of various shapes and designs.

Glass blowing was a fine art, requiring long apprenticeship and experience. Prior to molds, the glass blower relied upon massive lung power plus the use of shaping tools or, in some cases, only twirling skill to create the shape of his container.

After the introduction of molds, the glassblower simply lowered the red-hot glass bubble into a hollow mold and blew until the bubble expanded to assume the shape of the inner wall. This system produced more uniform containers and provided more decorative possibilities.

The One-Third Mold

For a time the one-third mold was popular—a handmade mold actually about one-third the size of the intended finished product. A hot glass bubble was blown into it and allowed to cool only slightly; then the mold was released. The container was blown to the desired size retaining a proportionately enlarged shape of the mold.

Glass was molded and blown in this way before 1900. Thereafter, mechanical devices and improvements led to the invention of the first glass machine, with consequent progress in glass manufacture and in molds.

In the early 1900's, with the advent of semi-automatic machinery, molds became an important factor in production. Normal output was one mold per day per man. They were made of any kind of cast iron, and were produced on a "hit-and-miss" basis. Molds were used as they were made, and if they failed to perform properly, or broke down during use, they were simply returned to the shop's mold maker for further experimentation.

Because of slag and impurities in the inferior iron, two or three inches of additional metal was poured into the sand mold, so that "bad metal" could rise to the top and be cut off, leaving what was hoped to be a fairly workable mold. Up to 1920 it was not uncommon for as many as 50 molds to be poured before a "good" one was made.

Gauges cut from wooden cigar boxes were rubbed with chalk and placed in the mold cavity. If chalk marks appeared on the metal surface, the mold would be machined and cut down further. This process would be repeated again and again, until no chalk marks remained. Tolerances were as broad as 1/32 of an inch. Today's tolerances run in thousandths of an inch.

Fig. 4. Chill water being poured in foreground. In background, molten metal is pouring from Bull ladle into 500 lb. ladle.

In the early semi-automatic machines, molds were hand operated by means of a lever that forced the plunger into the glass and mold, shaping the glass into the contour. A boy usually operated the lever which opened and closed the half sections.

A New Industry

Probably one of the most outstanding changes in mold making took place in the middle '20's when commercial mold shops were expanded, creating a new industry. Prior to this time, each glass house maintained two or

Fig. 5. An electronic induction furnace, typical of modern equipment which provides highly specialized and controlled iron.

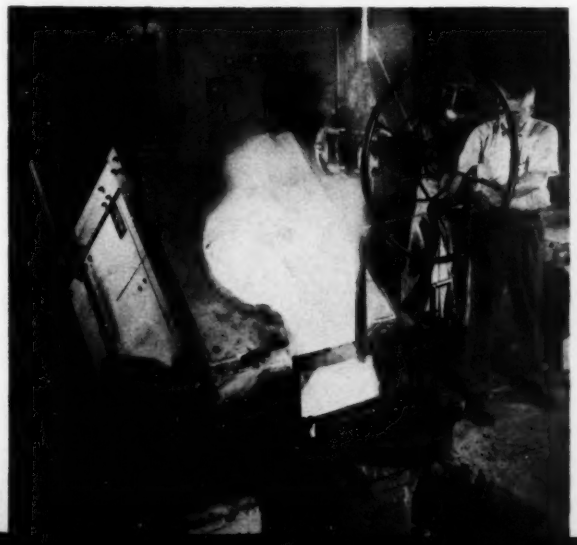
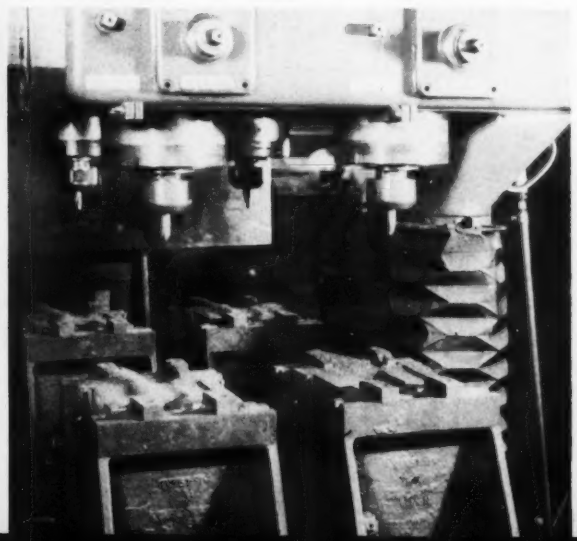


Fig. 6. The Duplicator—four cutters duplicate exactly the design followed by the tracer on the master.



Stage 1 of five stages of inspection following through production to guarantee adherence to specifications.

three men to make and repair molds. The profile lathe was brought into use and much headway was made in production. Gradually, other hydraulic machines continued to lessen manual labor and produce more accurate molds in shorter time.

Around 1927, inspection was instituted, eliminating to a great extent the "trial and error" method. This, coupled with the use of specific iron with controlled ingredients, provided dependable mold materials for the glass industry and afforded a definite decrease in glass production time.

Extremely hard tooling metal was adapted to the production of mold equipment in the early forties, further improving speed and mold quality.

Then, too, the designer influenced mold making from a practical standpoint. While the design departments in mold shops grew rapidly until 1948, this proved a short-lived service, as glass companies began to employ their own, or retain independent, designers.

Mold making was an art, with know-how and techniques handed down through families for generations. It was not uncommon to find grandfather, father and son working together in their specialized trade.

Machinery and engineering have marked another milestone in the mold industry, paving the way for mass production, time saving, and the elimination of human error in many cases, gradually replacing the experienced craftsman who, for years, combined skill with reason in prideful rendering of his talents.

Mold Making Today

Present day mold making is a highly specialized technical process, providing positive performance of molds with modern, high-speed automatic glass machines.

At Overmyer Mould Company, for example, the intricate process of producing a mold begins as a customer presents plans and specifications for a glass container especially designed for his product.

In the engineering department, a preliminary layout is prepared with accurate calculations such as volume and sizes, adaptable to the specified glass machine. Detailed drawings are made for blueprinting. For each new mold an average of 40 blueprints are made and distributed to each department involved in producing the mold. The processing department studies the blueprints for proper tools, jigs, fitters and gauges.

The pattern department prepares foundry patterns and models—the mold model, a duplicate of the article to be produced in glass, and the blank model, which will determine the amount of molten glass to be released from the glass furnace in order to produce a perfectly proportioned container. These models are usually made of wood or plaster. Plaster models are returned to the engineering department for approval. Master cases are then cast from the original.

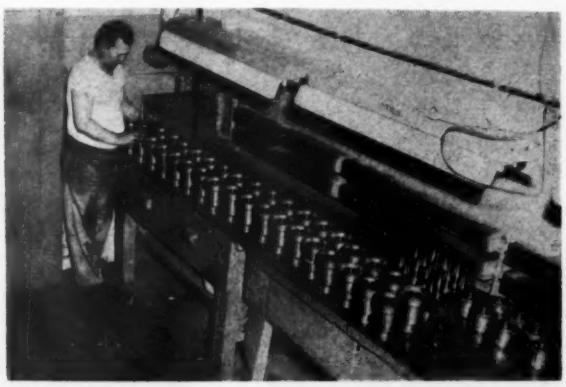
At the same time, chills are made from the blueprint specifications. The chill, a rough duplicate of the mold model and blank model, is made ⅛ smaller than the original models. One chill is made for each casting.

The function of the chill is to remove all possible iron, and, as the name implies, actually cool the iron quickly to achieve a dense, close-grained iron which will take a high polish where the glass will touch the mold.

At this stage, patterns and chill are ready to be placed in flasks of molding sand, compressed in jolt-squeezer machines which form the cavity in the desired shape of the casting to be poured.

Mold iron is comprised of three main ingredients, pig iron, limestone and scrap iron, plus special alloys to adapt each heat of metal to the customer's particular requirements. After the three principal ingredients are carefully weighed and measured proportionately they are transported in a huge bucket to the cupola where the mixture is melted by coke. From the cupola the mixture pours first into a huge Bull ladle and then into

Stage 2



Stage 3

smaller 500-lb. ladles. Here, special alloys such as magnesium, chrome, nickel, molybdenum, and vanadium are added by the metallurgist who guides chemical analysis and keeps a constant check on each heat of iron.

In some cases of special types of irons requiring more exacting control, or for smaller quantities, the mixture is melted in one of the electric induction furnaces, from which it is poured into smaller ladles.

Moving on an overhead monorail conveyor, the 500-lb. ladles are maneuvered into position for pouring the molten metal into prepared flasks. Approximately 1500 flasks are filled each day, or nearly ten million pounds of molten metal a year.

After pouring, the metal is allowed to cool and set up; then, "shaken out" and wet down in order to cool the castings.

In the cleaning room, gates and risers (excess metal which has risen in flask holes during the pouring process) are knocked off. Rough castings are placed in a tumbler, amid small metal shot, like BBs, which blast constantly over the castings to remove every particle of sand.

From the tumbler, castings are taken to the grinder to remove all rough edges, and are then transported to one of the 8-ton-capacity annealing ovens operated by both gas and electricity where they are subjected to 1700°F for one hour. This process eliminates hard spots in the iron, removes the strain to make iron machinable and stable. After an 8- to 10-hour cooling period, castings are removed at 500° temperature, allowed to cool completely, and delivered to the inspection dock to undergo rough inspection, counting and sorting, preparatory to production.

Back in engineering the models have been approved, gauges, drawings and master models are in progress. Water-displacement inspection determines volume or measurements of capacity of the container. Gauges are made to exacting specifications, ready for their place in production of the mold.

Having accumulated all the necessary tools, gauges, models and blueprints, a meeting is called for production scheduling. The meeting includes all department supervisors. Each receives the blueprint and special tools pertaining to the part he will play in producing the mold equipment and is briefed on peculiarities of the job and the promised shipping date.

Now finished production begins. Huge machines perform a variety of steps—machining the face of the casting, cutting molds to proper length, boring neck diameters and necks to shape, machining formed surfaces.

After thorough inspection, the molds are banded, and inspected again. The intriguing duplicating process follows: One precision-built machine is capable of producing four exact duplicates of the master mold. Working on the pantograph principle, the tracer follows the master, while four cutters duplicate the master lines exactly in four castings of specified size. This machine guarantees absolute uniformity in the intricate design, whereas previously, hand operations left variations, no matter how skilled the craftsman. Some molds require as much as 12 hours' work on the duplicating machine.

After the master has been faithfully duplicated and the mold inspected, the polisher takes over, smoothing the surfaces and removing every minute burr. Again, inspection is made.

During the time the mold is in production, the necessary items have been produced. Two 40-ton hydraulic planers assure precision and absolute uniformity in neck rings, in preparation for mass production.

After every operation, inspection takes place, as each new operation is dependent upon the accuracy of the preceding one. Highly sensitive precision instruments aid inspectors in their quest for variances.

The surface indicator, for example, measures the smoothness of the inside surface of a mold in micro inches. Machined measurement of micro waves removes the element of human error in visual inspection.

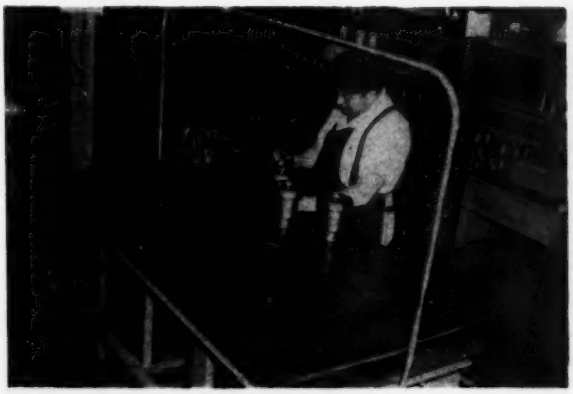
In the final inspection department, each mold undergoes rigid scrutiny for every detail, with the most modern instruments and gauges.

The mold is then ready to be put under glass on one of today's fast, fully-automatic glass machines.

Research

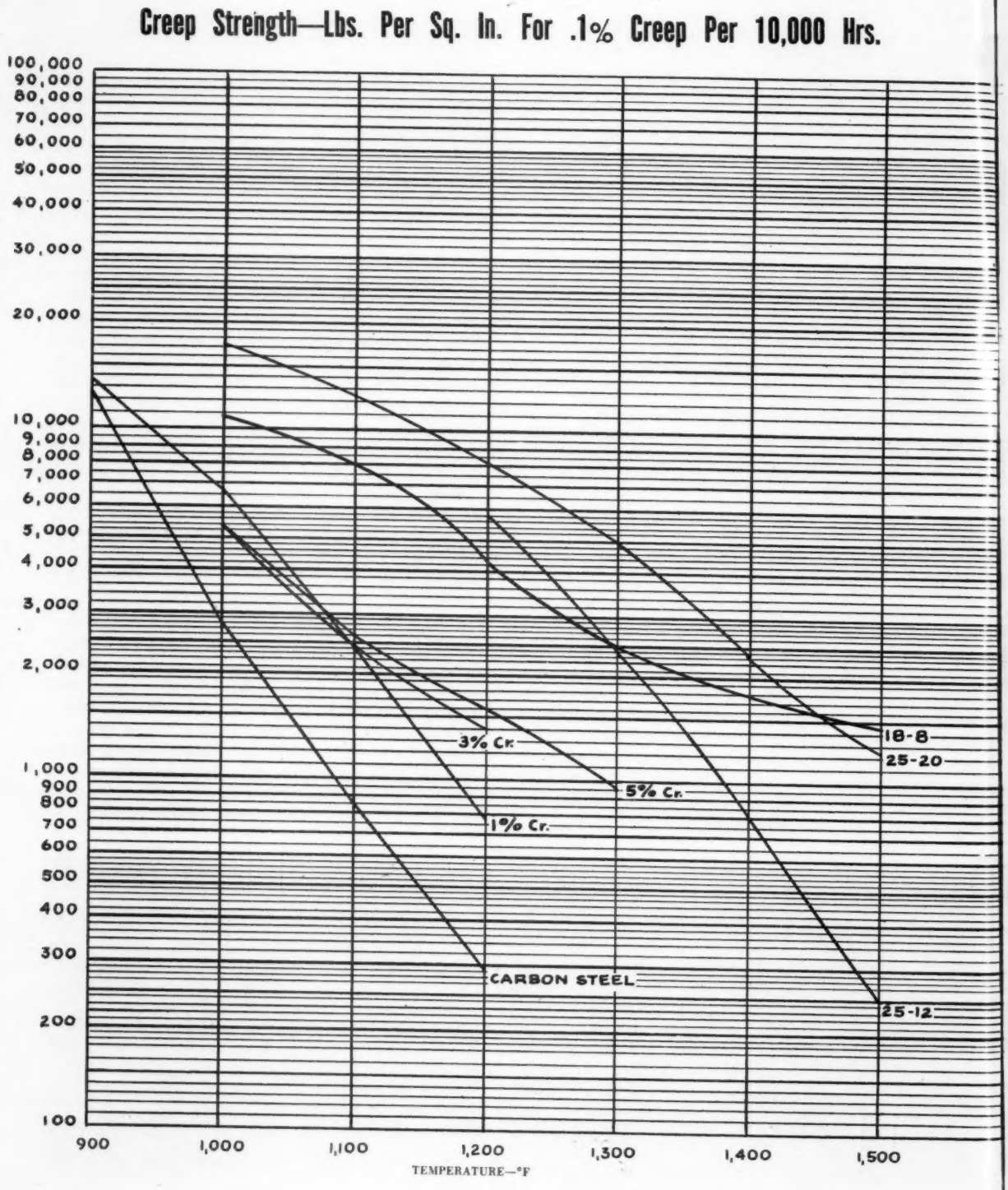
As in all fields, research leads to progress, and research in molds leads to finer glass-making materials which will help glass manufacturing eliminate production problems.

By means of a miniature glass furnace now being installed in the research department, Overmyer will duplicate production procedures in the glass industry and thereby hopes to achieve better, more machinable metals which will withstand higher heats without cracking.



Stage 4

Stage 5


Creep Strength—Lbs. Per Sq. In. For .1% Creep Per 10,000 Hrs.
100,000
90,000
80,000
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1,100
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1,300
1,400
1,500
TEMPERATURE—°F
3% Cr.
5% Cr.
1% Cr.
CARBON STEEL
18-8
25-20
25-12

Fig. 1

Effect of Higher Annealing Temperatures on Lehr Belt Alloys

by John B. Hanson, MANAGER, WIRE BELT DIVISION, THE CAMBRIDGE WIRE CLOTH COMPANY, CAMBRIDGE, MARYLAND

● As FASTER, MORE ECONOMICAL production is achieved in annealing and decorating lehrs, higher temperatures will be encountered. Which alloy of wire is best suited for the fabrication of the lehr belt designed to withstand the effects of these higher temperatures?

Under present-day conditions, temperatures encountered in glass annealing are actually the lowest of what might be called the "high-temperature" range for metal-mesh conveyor belts. While most glass is annealed at about 1100°F., metal-mesh belts are today performing other duties in other industries at temperatures as high as 2100°F. Applications approaching this range are most numerous in the metalworking industry and also occur frequently in the ceramic industry.

For operation in the glass annealing range with moderate loads, speeds and temperatures the high carbon steels have proven adequate. Carbon steel, however, has a disadvantage in that two of the scale constituents are ferrous oxide and ferroso-ferric oxide. Under equilibrium conditions they undergo a phase change at about 1040°F., with a resultant instability and spalling of the scale which tends to mark the ware.

Under actual operating conditions in a lehr this phase change will occur at a somewhat higher temperature, depending on belt speed, wire diameter, heat capacity of the ware, internal heat circulation of the lehr and additional compounds in the scale other than ferrous oxide and ferroso-ferric oxide. Thus an operator utilizing a carbon steel lehr belt in the temperature range above the phase change temperature runs the risk of creating a loose, easily spalled scale on the wire.

It is also in this temperature range that the creep strength of carbon steel begins to decrease rapidly, and hence it becomes necessary to go to a stronger, more oxidation-resistant alloy. This is accomplished by using a 1 per cent chromium alloy steel. The chromium serves the dual function of strengthening the alloy and providing a chromium-rich scale which is more resistant to spalling (Figs. 1 and 2). With a small increase in belt cost this alloy provides excellent strength and oxidation resistance for the temperature range up to 1100°F.

For the higher temperature range encountered in glass decorating lehrs it becomes necessary to increase further the chromium content in order to provide adequate oxidation resistance and strength. This is accomplished in the temperature range up to 1200°F. by the utilization of a 3 per cent chromium alloy.

In gold and other decorating processes reaching temperatures up to 1400°F. it is necessary to increase the chromium content again. At this point the chromium

(*Continued on page* 660)

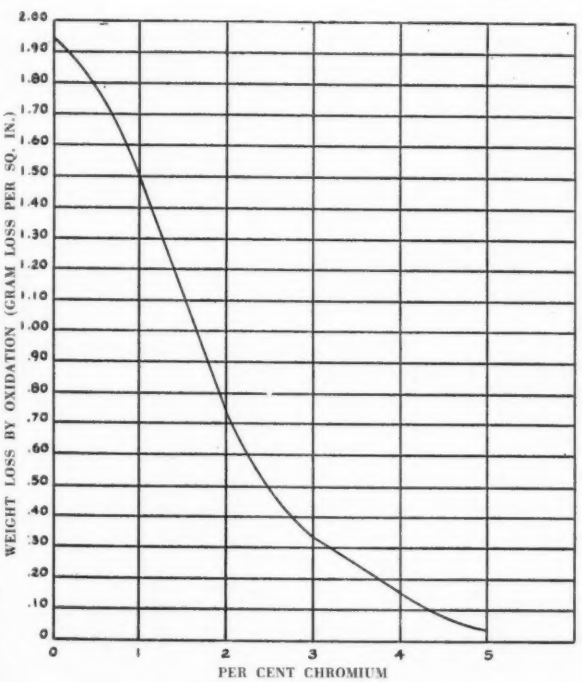

Fig. 2. Oxidation Resistance at 1250° F.

Highlights in the Glass Industry 1920-1959

1920-21 After extracting green sands found in New Jersey, The Eastern Potash Corp. of New York will use this residue for the manufacture of silica-lime brick.

Simulated glass to be used to manufacture a kind of mother-of-pearl glass; first steps taken by German technologists.

Plant for glass tubing by machinery installed at General Electric, Fostoria, Ohio.

Capacity of power plant doubled at Corning Glass Works.

Automatic lehr feeders and conveyers employed by Owens Bottle Co. This move brightened the business prospect for the years ahead.

Oil burners in place of coal used in most of the factories now.

Largest automatic feeder built by Miller Glass Engineering Co. now being installed at Jeanette Glass Co. Adaptable for dropping compact gobs of glass to 250 ounces directly into a mold without the aid of a chute at a speed of 25 per minute.

First glass factory erected in Albany by Hires Turner Glass Co.

G. A. Shields Co. showing new flowing glass machine that cuts hot glass to size and turns out window glass, wire, Florentine and other glass with equal facility.

High percentage of silica found in sand near Jacksonville, Fla. is basis for erection of plant by Tidewater Glass Co.

Representative of various branches of the U. S. Government move to standardize sizes and grades of glass used in building.

Zirconium oxide as an opacifier in the manufacture of white glass was found successful in experiments in Germany.

1930 New glass tube manufacturing plant at Corning Glass Works.

Reduction of glass tariffs voted by Senate.

Libbey-Owens and Edward Ford Companies merge to form Libbey-Owens-Ford Glass Company.

Reduction in number of motor cars manufactured this year will lead to lower prices in the plate glass market unless overproduction is checked. Also, cars will be smaller thus reducing amount of glass required.

Manufacturers of laminated glass for automobiles turned attention to the production of sheets of this material decorated by the method of coloring the plastic layer which holds the two sheets of glass together.

H. L. Dixon Co. announces completion of plans for marketing of what they believe to be the first lehr for entirely electrically annealing all sizes and shapes of ware and automatic handling of it from the forming machines to the packer.

Glass cylinders used for gasoline filling stations now being investigated by Underwriters' Laboratories of New York.

1940 Straddling the road at the top of a rise, the Traffiscope gives the man at the wheel a clear view of what lies over a hill so that he may know if danger lies ahead.

The Glass Age has become so important that words referring to glass in any way have been properly defined and put into the newest edition of Webster's unabridged dictionary.

The static charge acquired by chemical glassware when wiped may cause a serious error in weighing the vessel, especially in winter months when the moisture content of the atmosphere is low.

Owens-Illinois Glass Co. announces Duraglas, a new technique in glass making that results in a stronger and more durable container than heretofore possible.

Corning Glass Works has legal right to the name "Pyrex".

"History of Glass" so outstanding at the World's Fair it has been permanently donated to the Museum of Science and Industry, Chicago.

U. S. Navy Department announced the adoption of Fiberglas as a standard insulating material for deep-sea divers. Developer and manufacturer of this suit is Colvinex Corp.

1950 Corning Glass Works' new pilot plant is first of its kind in the glass industry.

Rich deposits of large quantities of fine, white silica sand and bluish-gray clay pave the way for a glassmaking industry in Manitoba, Canada.

A secret, wartime method of mass producing Schmidt corrector plates, a lens ten times faster than a high-speed camera lens, has been revealed by the American Optical Co.

Dunbar Glass Co. becomes the country's first glass manufacturer to utilize air transport for a full cargo plane of glassware.

New all-glass rectangular bulb will go into mass production because of need demanded by television.

Corning Glass Works announces the development of a new electrically conductive opaque coating for the inside surface of television picture tubes that will eliminate the need for carbon coating the bulb by hand methods.

Pittsburgh Corning Corporation's new PC glass blocks for a more uniform panel appearance and better brightness control are now available commercially.

Northwestern University develops an arsenic sulfide glass of high transmission in the infrared which can be molded easily.

Owens-Corning Fiberglas has announced a non-woven scrim fabric of Fiberglas yarns for reinforcement of papers.

The development of an insulating type window unit made of two panes of sheet glass with a pocket of dry air sealed in by a metal-to-glass bond makes it practical to design solar type farm buildings to take advantage of the sun's heat in winter. This is known as Thermopane.

American Optical Co. is now mass producing the largest glass television mirrors ever used.

University Plate Glass Co. is now producing Lamiglass, a 2-oz. sheet glass to be used exclusively for laminating purposes.

University of Pittsburgh succeeded in developing several new radiation-absorbing glasses which seem to possess immediate importance for protecting the eyes of atomic energy, atom-bomb, and hydrogen-bomb workers from radiation cataracts.

Mold-smoking is a recently-introduced process for lubricating molds used in producing glass bottles.

McKee Glass Co. develops giant TV mirror blanks to fill a large theatre screen with a clear and brilliant image.

Mirrors that reflect one color of light are in daily use at Westinghouse Electric Corp. for exploration of new methods of transmitting and receiving color television pictures.

Futuristic dream car made practical by technological advances in glass manufacture at Pittsburgh Plate Glass.

Libbey-Owens-Ford develops new Shaded Windshield to block rays of ultraviolet light while admitting more than 70 per cent of the visible daylight.

1951 Corning Glass Works celebrates 100th anniversary.

Cadmium to be used for certain highly essential non-defense purposes, and plans for a longer-range program to stretch supplies of this commodity to meet both defense and other important requirements discussed at Cadmium Industry Advisory Committee meeting.

O. Hommel Co. entering its 61st year as a leading manufacturer and supplier to the ceramic industry.

Pittsburgh Corning Insulation Research Bureau reports new method of applying the lower layer of cellular glass insulation to ceilings without mechanical support.

General Electric Company develops a process by which glass can be soldered to metal making a bond stronger than the glass itself.

Pittsburgh Corning Corp. announces the development of the PC Daylighting Nomograph which makes it possible to predict daylight levels in a room before the building is constructed.

Electro-luminescence lighting called "Panelite" developed by Sylvania Electric.

General Electric Co. developed a temperature control system which automatically maintains a constant white heat for the production of glass "threads" 60 times finer than a human hair.

General Electric Research Laboratory has new transparent screen for TV tubes that will make a greater contrast between light and dark areas.

A new process for dyeing fibrous glass has been developed by General Aniline and Film Corp.

New, improved heat-absorbing plate glass has been produced by L-O-F.

Process of cathode ray tubes for color to permit a true and intensified translation of all colors of the spectrum evenly has been developed by Sightmaster Corp. for TV.

Corning Glass Works develops photosensitive glass which can be precision-machined through the use of ultraviolet light, heat, and hydrofluoric acid to form intricately cut patterns of any desired shape and depth.

Giant image-correcting lens for projecting improved 15′ x 20′ TV pictures on movie screens announced by American Optical Co.

L-O-F makes its first fiber glass.

A super-sensitive glass worn like a GI dog tag now being used to detect amount of radiation men are exposed to. Developed by Bausch & Lomb.

1952 Ordinary colorless glass will eventually be replaced by Pittsburgh Plate Glass' new greenish tint glass which absorbs the sun's heat, reduces eyestrain, and keeps fading and bleaching fabrics to a minimum.

Cambridge Wire Cloth Co. announces Cambriloy-Al. a new material for fabricating woven wire conveyor belts for annealing and decorating lehrs in glass manufacturing plants.

Hard-boiled fire helmet molded Fiberglas with natural insulation against heat developed by E. D. Bullard Co.

Ultralite, weight-saving insulating material produced by Gustin-Bacon has been installed on Pennsylvania Railroad's streamliner trains.

"Garan Finish" patent purchased by L-O-F. Surface treatment applied to glass fibers to give them superior characteristics for reinforcing plastics.

Ferro Corp.'s "Fiberflash", custom-built sports car with a one-piece, fiber glass-reinforced plastic body unveiled.

New construction material with many potential applications in the building trades described by Armour Research Foundation.

Corning Glass Works' photosensitive glass used for U. N. General Assembly Building.

Quartz, the crystalline form of silica and the most perfect electrical insulation material found in nature, has been duplicated chemically in the form of fibers by Glass Fibers, Inc.

1953 First glass stainless steel tank, for super-corrosion resistance for storing fuming nitric acid will be produced by Pfaudler Co.

New prismatic glass panel for fluorescent lighting fix-

tures called Pattern No. 70. Low Brightness Lens Panel developed by Corning Glass Works.

Mathieson Chemical Corp. developed new coarse, light soda ash product suitable for glass making.

"Fiberglas Corotop" for fast, economical maintenance of asphalt roofs announced by Owens-Corning Fiberglas.

Kristal Kraft, Fiberglas-reinforced plastic used to repair boats.

Alexander H. Kerr & Co., Inc. introduces "Rippolite" a new translucent rippled, structural panel.

Skytrol Glass Blocks for use in skylights announced by Pittsburgh Corning Corp.

"Vibraglass", glass fiber resilient board material now being used as an aid for packaging delicate materials.

Flexible Duct Liner, Fiberglas insulating product for lining the interior of air conditioning or warm-air ducts has been introduced by Owens-Corning Fiberglas Corp.

"Twindo-Weld", first all-glass double-glazed insulating window introduced by Pittsburgh Plate Glass.

New glass seal Thermopane insulating window unit developed by L-O-F after many years of research.

1954 For the first time in consumer glass cookingware history, McKee Division of Thatcher Glass Mfg. Co. offers lifetime guarantee with all Glasbake items.

Pittsburgh Corning introduces "Suntrol" glass blocks to reduce glare and solar heat gain.

A locket-size glass device that records the radiation to which it is exposed was made available by Corning Glass Works.

The world's first synthetic mica plant under construction in Caldwell, N. J.

Development of a central adhesive colored core has made possible the manufacture of a new type of color panel. Process developed by Marks Polarized Corp. is called "microlamination."

Wheaton Plastics Co. develops plastic glass-lined aerosol container.

75,000 watt electric lamp—largest ever made—blown by Corning Glass Works.

Brockway Glass Co. and General Electric Co. disclose that silicone coating process on glass makes containers more rugged and attractive.

Corning Glass Works develops automatic machine to produce glass capacitators at rates up to 30 times faster than present manual methods.

New glass-to-glass sealed insulating unit announced by L-O-F.

New, non-combustible Stria Acoustical Tile for decorating ceilings announced by Owens-Corning Fiberglas.

Production of a new, high-density, compressed fibrous glass material with excellent shock and vibration-borne sound absorbing qualities announced by L-O-F.

1955 New, slender long-tip pipette developed by Kimble Glass for easy insertion into apparatus with narrow openings.

Pittsburgh Corning develops cellular glass insulating material which combines both insulation and ceramic finish in a single unit.

New Fiberglas screening in a "do-it-yourself" kit made by Lifetime Fiberglas Screening Co.

Glass transmitting a greater range of infrared rays has been developed at Battelle Institute from oxides of antimony.

Multi-colored glass buildings now possible because of "Spandrelite" developed by Pittsburgh Plate Glass.

Alsynite Co. of America introduces "Flat Panes" for a wholly new concept in industrial daylighting—the use of shatterproof, fiber glass factory window panes in a variety of built-in colors.

L-O-F announces that its glass yarn is now being used in fiber glass screening. This new material is called "Glasscrene" and is manufactured by the Federal Screen Supply Co.

General Electric Lamp Division develops 200-watt PAR-46 flood lamp of the all-glass sealed-beam type for many indoor and outdoor needs.

Institute of Silicate Research develops a method for the measurement of extremely small forces acting upon immersed solid samples.

"Sun Glasses for Buildings" to increase efficiency and visual comfort on critical work is the latest development of Houze Glass Corp.

Bausch & Lomb Optical Co. has developed an improved sphere generator for precision contouring of round quartz crystals on a mass production basis.

New Owens-Illinois Technical Center opens in the western section of Toledo.

Harbison-Walker Refractories Co. opens new plant for the manufacture of silica refractories at Leslie, Md.

White Cap Co. acquired by Continental Can.

1956 Haddam Manufacturing Co. has developed a new method of bonding copper and copper alloys to glass.

Spectacle Lens Tester to measure both central and marginal powers of a spectacle was developed by the National Bureau of Standards.

Minnesota Mining and Manufacturing developed an aluminum-coated fabric that reflects radiant heat instead of insulating against it therefore enabling a man to work in heat 1/8 as hot as the sun.

Pittsburgh Plate Glass Company's new curved-windshield manufacturing plant received "raw material" for its fabricating operation from their large plate glass manufacturing operations.

Ladd Research Industries produces micrographs that show overlapping lead particles and similar structure details previously indiscernible.

Lee W. Minton, President of the Glass Bottle Blowers Association, moves toward merger of the 3 unions in the glass industry.

Development of an improved glass fiber-reinforced plastic will be undertaken by Houze Glass Corp.

Owens-Illinois plans multi-million-dollar bottle manufacturing plant at San Jose de las Lajas, 20 miles southeast of Havana.

Latchford-Marble Glass Co. designed a new acid micropump which has helped solve a water conditioning problem.

Merger of Owens-Illinois Glass Co. and National Container Corp. was authorized by directors of both companies.

A new graphic method for quick selection of patterns

for loading 20,000 sizes of containers on the 40" x 48" pallet has been devised by the Navy.

1957 A 50 per cent increase in modulus of elasticity of fibrous glass was achieved in recent research for the Air Force by the continuous formation of fibers of a calcium aluminate glass in a small textile glass bushing.

National Bureau of Standards shows that the distortion in the image produced by a projection lens can be readily calculated as a linear function of the magnification.

Production of images on flat panels, by combining the sciences of lighting and electronics was developed by Sylvania Electric Products Co. and is called Sylvatron.

A flat borosilicate glass, featuring high resistance to thermal shock and chemical action, is being introduced nationally by Blue Ridge Glass Corp.

Columbia-Southern explores Liberia for titanium bearing ores.

B. F. Drakenfield announces that commercial selenium is now available in normal quantities after a shortage caused by the Korean War.

Richard C. Remmey & Son Co., now a wholly owned subsidiary of AP Green Fire Brick Co.

An unusual floating pump house is feeding 14 million gallons of process water a day to the Ford Motor Company's new glass plant near Nashville, Tenn.

International Minerals and Chemical Corp. introduces "Kona Super Sand", a new product combining unique properties particularly useful in glass, ceramic and chemical manufacturing.

Blue Ridge Glass Corp. introduces a flat borosilicate glass featuring high resistance to thermal shock and chemical action.

1958 Precision bore 96 per cent silica glass tubing with inside diameter tolerances up to ±.0005 inches has been announced by Corning Glass Works.

Corhart Refractories Co. has developed a method of precision-forming tiny cores in high-temperature metal casting by fixing glass tubing to the inside of a precision casting mold before pouring.

Pittsburgh Corning Corp. has created an entirely new acid-resistant insulating and refractory material by causing pure silica to boil and foam, called Foamsil.

New light bulb with special electrostatic silica coating developed by Westinghouse.

Pittsburgh Plate Glass develops new TV tube by laminating glass and plastic therefore making it possible to eliminate the separate front window.

Corning Glass Works has developed a new method of glass lamination which is being introduced in a shatterproof, dustfree contoured twin panel TV tube.

Corning Glass Works has introduced thin-walled ceramics which have been formed into lightweight honeycomb structures capable of operating at high temperatures.

Westinghouse Electric to begin production of quartz tubing.

L-O-F forms engineering fuels and instrumentation group to improve technical service to glass company plants.

The world's largest window glass tank furnace was recently put in operation at Zeebrugge, Belgium.

M.I.T. completes full-scale sun-heated house, first of its kind designed to meet modern living requirements.

Sylvania Electric Products develops a "ceramic-in-glass" electron tube by adapting the principles of the "stacked" tube for use in the conventional glass envelope or bulb.

L-O-F Glass Fibers and Johns-Manville propose merger.

Westinghouse Electric Corp. announces new method for converting heat directly into electricity through use of thermoelectric materials.

American-Saint Gobain Corporation was formed in May, 1958, by the merger of American Window Glass Company, Pittsburgh, Pa., and the Blue Ridge Glass Corporation, Kingsport, Tenn., a wholly owned subsidiary of Compagnie de Saint-Gobain, Paris, France.

1959 Owens-Illinois establishes metallurgical research and service section.

Garber Research Center of Harbison-Walker Refractories formally opened in Pittsburgh, Pa.

Fischer & Porter formed Warminister Fiber Glass Co. for production of fiber glass reinforced plastic parts.

Museum of Glass, tracing glass-making history back 3,500 years opens in Tel Aviv.

Republic Glass Corp. opens first window, sheet and plate glass plant in the Philippines, located at Manila.

American-St. Gobain plans to build a $50-million flat glass plant in the Ohio Valley area.

H. K. Porter's refractories division has begun full production of the first basic refractory called Plastikrom.

L-O-F develops a shaded scenic back window for General Motors cars incorporating advanced ideas for the control of light and solar radiation.

Corning Glass Works has developed a new, moisture-proof glass capacitator.

Kimble Glass Co. announced a new method of firing a colored ceramic finish on a glass block at a very high temperature, causing the color to fuse with the face of the block.

American Optical Co. develops new periscope for tanks and jets.

Union Carbide Corp. has new process for dyeing fiber glass cloth.

Atomic Energy Commission converts atom heat directly into electricity by means of a new generating system called a "plasma thermocouple."

L-O-F Glass fibers sold to Johns-Manville Corp.

Westinghouse Electric Corp. designs a single-ended fluorescent lamp of high efficiency which can be mounted in one socket similar to the conventional incandescent lamp.

Chrysler Corp. plans to begin manufacturing its own glass early in 1960.

Brockway Glass and Tygart Valley Glass agreed on a statutory merger that will make Tygart a wholly owned subsidiary of Brockway.

Columbia Southern begins operating its new multi-million-dollar soda ash and sodium sesquicarbonate plant at Bartlett.

TEN YEARS OF PROGRESS IN THE GLASS INDUSTRY 1948–1958

by H. E. Simpson
STATE UNIVERSITY OF NEW YORK COLLEGE OF CERAMICS
ALFRED UNIVERSITY, ALFRED, N. Y.

● GLASS, ONE OF MANKIND'S OLDEST manufactured products, is today being produced, sold, and used in greater quantity than ever before. Chief reasons are the building boom, increasing automobile requirements, greater demand for glass containers, continued growth in the electronics industry, constant expansion in the glass fiber field, and the unlimited possibilities unfolding as we enter the Space Age.

Glass can be fragile or tough; transparent or opaque; it can transmit heat or stop it; can pass electricity or block it. Indeed the versatility of glass makes it one of the most valuable materials of modern industry. By different compositions and manufacturing methods, it is possible to produce glasses with predetermined characteristics, to solve many specific problems such as those involving corrosion, heat, cleanliness and abrasion.

Medical science would be seriously handicapped without glass. There are hypodermic syringe parts of the glass "boot" that work miracles of healing in arterial disease cases; microscope lenses; germicidal lamps whose ultraviolet rays free the air of germs; and there is a tiny electric glass lamp, no larger than a grain of wheat, which glows at the end of a bronchoscope enabling a doctor to see inside the bronchial tube.

Glass windows are constantly being used in greater areas for automobile glazing; glass fenestrations are playing an increasingly important role in the air-conditioned home and office building. The entire problem of heat control in buildings will demand more glass in the form of flat glass, glass blocks, and fiber glass as insulation.

Industrial television represents a tremendous potential for glass products. Because of its small size, relatively low cost, and extreme flexibility, closed-circuit industrial television has limitless applications in industry, science, business, education, and numerous other fields.

Closely allied to television, but having application in all fields of communication, is microwave relay equipment, which, within the next five years, may represent one of the most comprehensive systems of communication in the nation. Because it is more efficient and less costly, the microwave system is rapidly replacing conventional open-wire telephone lines, lead-sheathed cables, and co-axial cables in television, telephone, telegraphy and other fields of communication.

Glass in electronics is closely allied to the demands of television.

Somewhere in the future, and perhaps not too far off, the glass industry will be furnishing vital parts for the manufacture of electronic air conditioning, electronic ignition systems, and other revolutionary devices.

Electronic sound-synthesizing devices have been developed which can, in theory, duplicate any sound, including musical notes and human voices. These devices can synthesize sounds never before heard on earth, literally bringing to man the music of the spheres.

There is an electronic cooling device in which 6 ounces of ice have been frozen. This is believed to be the first instance of attaining a freezing temperature in a sizeable area without mechanical refrigeration.

In other areas, the electronic light amplifier may lead

to the possibility of making vision possible in darkness, adding greatly to the safety of all transportation.

It is important to imagine the future of electronic light. One certainty, though, like other major scientific innovations, is that it will cause the creation of entirely new instruments, appliances, services and industries.

Probably the most challenging of tomorrow's products is the variable transmission window whose opacity to light and radiant heat will be adjusted either manually or automatically.

Electroluminescent panels, for lighting the interiors of homes and offices, are already being developed in the laboratory. These panels give off a low intensity of light when an electric field is applied to them, representing an extension of the mercury light concept. A mercury light has much lower intensity than the incandescent lamp, but the increased area results in a higher light value. The most practical base on which to apply these electroluminescent coatings is glass.

This type of electroluminescent lighting is being used in the instrument panels of some 1960 cars.

In the future, glass will serve not only as a decorative and durable surface for walls and ceilings, but it will also provide a base for coatings which will produce soft light for room illumination.

Glass covered with electrically conductive coatings has been used successfully as a source of heat. In the future, electrical energy will generally become lower in comparative cost, and this method for the controlled heating of buildings will be increasingly common. Coated glass will be the most practical medium for supplying long-lasting heating elements for completely enclosing and decorating rooms.

The conservation of energy is always an important factor. Fossil fuels, like coal, may be partially replaced as a source of energy, by nuclear fuels.

Scientists are returning to, and emphasizing, the sun as our principal source of available energy. In solar heat, glass will be used as a filter to allow the entrance of radiant heat into enclosures, where it is absorbed; and also as a barrier to prevent the escape of heat by convection and conduction once it has been captured. Glass is being used today for this purpose. There are certain applications where the temperature reached by direct sunlight is not sufficiently high. Under these circumstances, it is desirable to increase the temperature by collecting the sun's rays over a large area and concentrating the energy in a smaller area.

Reflecting mirrors for collecting the sun's rays will grow in importance, and most of them will be made from glass. In the not-too-distant future, such collectors will be able to furnish considerable quantities of power competitively in some parts of the world. In the more distant future, following the inevitable degradation of other power sources, enormous glass collectors will furnish very significant amounts of energy throughout the habitable world. Here could be one of the most extensive new mirror markets in many years.

Unbreakable glass will result from the extensive basic research being conducted today into the structure of glass, and the extension of its properties by new compositions. This product had long been talked about, but only recently have some of the puzzling mysteries surrounding the very old art of glass making been solved.

Such an unbreakable glass could compete directly with metals in many areas. Machinability is a characteristic not normally associated with today's glass, even though sand blasting and ultrasonic methods can now be used to fabricate glass at a cost that is satisfactory for very special purposes. Unbreakable glass, however, would probably be machinable to an extent approaching that of metals.

As a packaging material, glass possesses certain qualities unmatched by any other material. It is chemically inert, impermeable, transparent, nonporous, sanitary, and odorless, and may be formed into an infinite variety of shapes and sizes in many colors.

Looking into the future, it is possible to see that glass —with its $10,000,000 annual investment in research and development—is on the threshold of a new era.

Since 1930 most glass containers have shed a third of their weight, and a further slimming of 20 per cent has already been predicted for many styles of glass containers in the future—making lighter and even stronger glass containers no longer a matter of conjecture.

The modern glass container is capable of withstanding much more abuse than is generally believed. Proof of the strength and remarkable shipping qualities of modern, improved glass containers may be found in the Final Report of the Transportation and Packing Survey, sponsored jointly by the Railroads of U.S.A., and the Fibre Box Association.

Freight claims on foods and beverages in glass averaged $10.00 per car against $55.00 for juices in tin, and $44.00 for fruits and vegetables in tin.

The freight claim average of all commodities checked by the railroads is $29.00 per car, compared with $10.00 for glass.

Present-day glass production is expected to continue unabated. With the arrival of the Space Age and lunar probes, it is quite logical that the glass industry will direct its attention to studies in the satellite field. A broader use of glass is anticipated in this field, with the newer glasses having unusual and specific properties.

Glass-ceramic products will multiply; electronic glasses will be used widely here.

ACKNOWLEDGEMENT

The author is particularly indebted to Dr. S. Frank Cox, Director Emeritus, Pittsburgh Plate Glass Company, for his aid and many helpful suggestions in the preparation of the following ten-year review in glass.

Much data and statistics for the work were taken from United States Department of Commerce Bureau of Census; "Glass Containers 1958" of the Glass Container Manufacturers Institute Inc., and "Fact Book 1959" of the Electronic Industries Association.

The remaining information was obtained through the kind cooperation and correspondence with the various companies throughout the glass industry. Such help is gratefully acknowledged and without it a presentation of these records would not have been possible.

TEN Years of Progress in the Glass Industry

GLASS CONTAINERS

● THE GLASS CONTAINER is one of the oldest forms of packaging, and, in spite of the competition of new materials, their use is rapidly increasing—much faster in fact than either (Chart 1) population or consumer disposable income.

The trend line for sales of corrugated and solid fiber shipping containers is included in Chart 1, because this trend has been found to represent closely the over-all packaging industry. It is interesting to note that glass container usage, following its post-war low in 1949, has advanced faster than the over-all packaging trend.

The extraordinary growth of the entire glass container industry from 1930 to 1958 is illustrated in Chart 2. Total glass container shipments have grown from approximately 5.0 billion units in 1930 to 21 billion units in 1958.

Dollar volume of new glass containers in 1958 totaled $822,000,000, and the dollar volume of glass container closures, $289,000,000. The packaging industry is the nation's ninth largest, exceeded only by the automotive, petroleum, and aircraft industries. Steel ranks eleventh.

Chart 2 shows manufacturer's shipments of *new* glass containers.

Many purchasers, however, re-use the same bottle; for example, milk bottles average 33 trips; soft drinks, 25; and beer bottles, 23 trips.

Since statistics are available covering shipments of closures used on returnable glass containers, an accurate estimate of total sales of glass-packed units in the United States is possible. These figures show that in 1958 some 71.0 billion jars and bottles—or an average of 410 per capita—"went to market" in the United States. This is considerably more than any other type of rigid container.

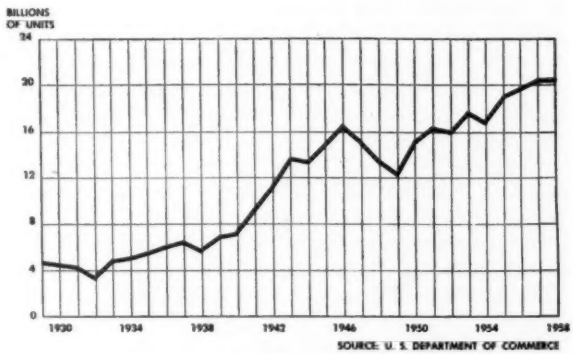

Chart 2. Glass Container Shipments: All End Uses.

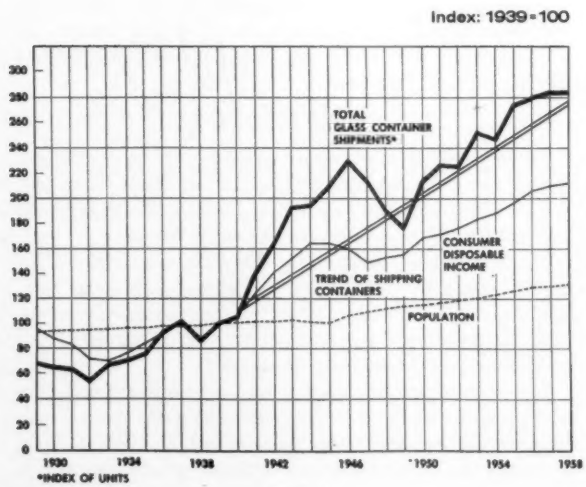

Chart 1.

For purposes of comparison, shipments of metal cans in 1958 totaled 41.5 billion units. American consumers in 1958 therefore bought approximately two items packed in glass for every one item packed in metal.

Almost all of the 42 companies engaged in the manufacture of glass containers produce the many styles of glass containers used in packaging. While literally thousands of different consumer products were packed in the more than 20 billion glass containers produced in 1958, all of these containers can be catalogued for convenience in one of four general end-use categories: food, beverage, drug and cosmetic, and chemical.

Chart 3 shows the growth of glass container use in these four categories.

These four categories account for over 40 per cent of the domestic total. Categories in which all, or a major portion of, the total goes into glass are: baby foods, salad dressing, mayonnaise, preserves, jams and jellies, catsup

and chili sauce, pickles and relishes, green olives, honey and soluble coffee. Glass containers used for food products totaled 57,777,000 gross (8,319,888,000 units) in 1958.

In 1939, only 13 per cent of the baby food was packaged in glass; at the end of 1958, it is estimated that more than 75 per cent was shipped in glass—almost completely revolutionizing baby food packaging.

The success of soluble coffee is another example of the many food products that have benefitted from the functional advantages of glass. Instant coffee has more than quadrupled in sales since 1951; glass is now used almost entirely in this field.

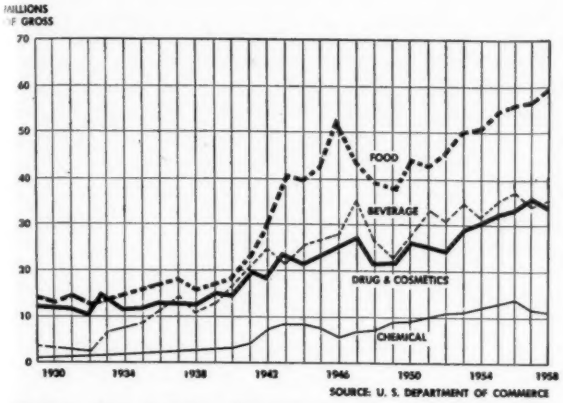

Chart 3. Glass Container Shipments By End Use: Food, Beverages, Drugs and Cosmetics, Chemicals.

Specialty food items in glass jars which have shown potentials for growth include powdered cream and cheese spreads. More and more processed vegetables and fruits, particularly apple sauce, are packed in glass. Tumblers, too, continue to climb in popularity for packaging such items as peanut butter, jams, jellies, olives and popcorn.

Because of metal shortages during the war years, many food packers switched to glass, giving consumers—in many instances for the first time—the opportunity of buying glass-packed foods (see Chart A). Following a slight postwar decline and leveling off, shipments of new glass containers resumed their climb, reaching an all-time high in 1957 and 1958.

Glass container shipments for the beverage industry, which includes wine, liquor, beer and soft drinks, have shown rather wide fluctuations, but the trend has been steadily upward (Chart 5).

Use of bottles for beverages in 1958 divided as follows:

	Gross	Units	Percentage of Domestic shipments
Wine and Liquor	13,924,000	2,005,056,000	9.9%
Beer	11,297,000	1,626,768,000	8.1
Soft Drinks	9,942,000	1,431,648,000	7.1
Total	35,163,000	5,063,472,000	25.1%

Glass is the only packaging material which has proved feasible in the beverage field up to the present time. Today, virtually all wine and liquor is glass-packed. In 1958, total domestic shipments of wine and liquor bottles totaled 13,924,000 gross (2,005,056,000 units)—equal to 9.9 per cent of all domestic shipments.

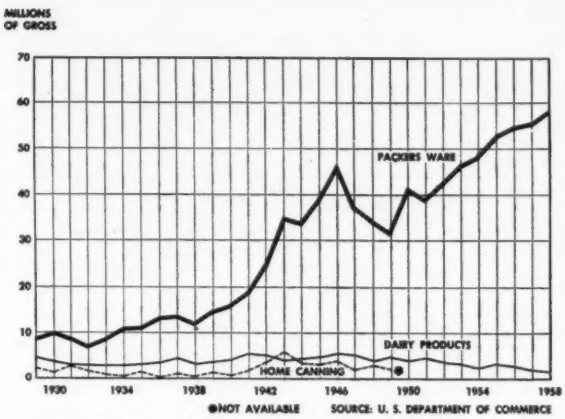

Chart 4. Glass Container Shipments for Foods: Packers Ware, Dairy Products, Home Canning.

Breaking this figure down, liquor bottles totaled 9,454,000 gross (1,361,376,000 units)—or 6.8 per cent—and wine bottles, 4,470,000 gross (643,680,000 units)—or 3.2 per cent.

Consumption of distilled spirits in 1958 totaled 215,465,000 gallons or 1.24 gallons per capita.

Movement of commercially produced wine from all sources was 153,998,000 gallons—the highest in the history of the industry, and 2.6 per cent above the previous year.

Glass-makers are fully aware of the convenience factor—for both consumers and retailers—of the no-deposit, non-returnable, one-way container.

Following the introduction of beer cans in 1935, glass container manufacturers developed the non-returnable beer bottle, in 1938. The non-returnable bottle for soft drinks was introduced in 1948.

During the twenty years they have been on the market, non-returnable beer bottles have far outdistanced returnables. The 1958 ratio of domestic shipments was almost four non-returnables to one returnable.

In 1958, non-returnables accounted for 8,604,000 gross (1,238,976,000 units)—or 6.2 per cent of the total domestic shipments, returnables for 2,693,000 gross (387,792,000 units)—or 1.9 per cent of all domestic shipments.

Domestic shipments of bottles (both returnable and non-returnable) for soft drinks in 1958 totaled 9,942,000 gross (1,431,648,000 units)—or 7.1 per cent of all domestic shipments. Of these, returnables account for 8,608,000 gross, (1,239,552,000 units)—or 6.2 per cent of the

End Use	Gross	Units	Percentage of Total Domestic Glass Container Shipments
Food	59,700,000	8,596,800,000	42.7%
Beverage	35,163,000	5,063,472,000	25.1
Drug and Cosmetic	33,526,000	4,827,744,000	24.0
Chemical (Household and Industrial)	11,459,000	1,650,096,000	8.2
Total	139,848,000	20,138,112,000	100.0%

Note: Manufacturers report figures in gross, a gross equalling twelve dozen, or 144 individual glass containers. Figures used herein all represent total in gross (followed by a unit equivalent). The accompanying charts are in gross with the exception of charts number one and two. Re-use has not been taken into account in the following material or in the charts. All percentages are based on figures for domestic shipments, excluding exports.

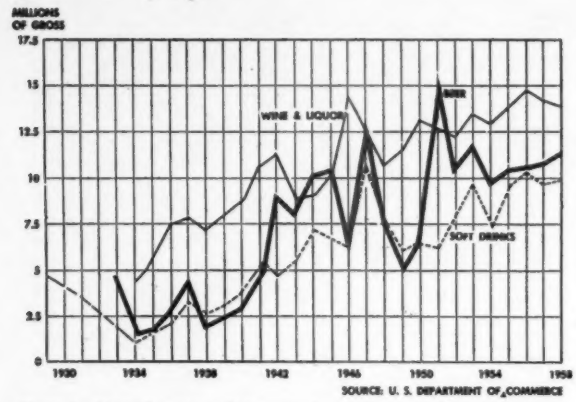

Chart 5. Glass Container Shipments for Beverages: Wine and Liquor, Beer, Soft Drinks.

total, and non-returnables, 1,334,000 gross (192,096,000 units), or 1.0 per cent of domestic shipments (Chart 5).

It is estimated that Americans consumed the astronomical total of more than 32 billion bottles of soft drinks in 1958, or 184.7 bottles per capita. Canned soft drinks were introduced in 1953, and accounted for an estimated 405,000,000 units in 1958. Since a large proportion of these are going off shore, this means that about 99 per cent of all soft drinks consumed in the United States during 1958 was in bottles.

In the soft drink field, over seven returnable bottles were shipped for every non-returnable one in 1958. Noteworthy, however, is the fact that, while shipments of non-returnables for soft drinks are still comparatively small, they have grown steadily since their start in 1948.

The figures indicate a very definite trend: 168,000 gross in 1950; 447,000 gross in 1952; 963,000 gross in 1954 (when interest was stimulated by the introduction of canned soft drinks); 1,188,000 gross in 1956; and 1,334,000 gross (192,096,000 units) in 1958.

The marketing patterns of canned beer and canned soft drinks are frequently compared with no consideration being given to the basic differences between the two products. It should be remembered that soft drinks carry a higher carbonation index than beer, and their acid and oxygen contents are also much higher. In consequence, packing soft drinks in metal presents different production problems from the packaging of beer in metal.

In addition to convenience and flavor, there is also the cost factor. Returnable bottles—which make many trips are by far the most economical package in the beverage field. Both bottlers and brewers pay less for non-returnable bottles (complete with labels and closures) than for cans. Further, the selling price of soft drinks is much lower than that of beer, making direct comparisons invalid.

And there are still other considerations which influence consumers in their choice between glass and metal, between returnable and non-returnable packages for beer and soft drinks. Among them are the questions of sanitation, product identification, ease of storage and handling, visibility of content, and eye appeal. What pattern consumer choice will take in returnables vs. non-returnables during the next five years, the next ten, is a matter of considerable interest to the packaging industry.

The drug and cosmetic industries have been wide users of glass containers. The growth in this field is illustrated in Chart 6.

From earliest days, drugs and toiletries have been packaged in glass. Bottles—together with the picturesque old apothecary jars—were the hallmark of old-fashioned pharmacies. And in today's modern drugstores—as well as in the drug and cosmetic sections of the vast new supermarkets, and in many department stores—an increasing array of products are packed in glass.

During 1958, shipments of glass containers for these products were 33,526,000 gross (4,827,744,000 units)—or 24.0 per cent of domestic shipments. As indicated on Chart 6, shipments have moved steadily upward since 1930.

Prior to 1944 (as with wines and liquors), neither manufacturers nor government agencies reported container shipments separately for drugs and toiletries. Subsequently, they did. In 1958 domestic shipments of bottles and jars for medicines and drugs were 20,730,000 gross (2,985,120,000 units)—or 14.8 per cent of the total, and 12,796,000 gross (1,842,624,000 units) for toiletries and cosmetics—9.1 per cent of total shipments.

In the medicinal and drug field especially—where the highest standards of safety and purity must prevail—many products demand the protection which glass alone affords.

Sales of toilet goods, cosmetics and perfumes stood at an all-time high of over one-and-one-half billion dollars in 1958. It is here that plastic containers have gained ground. Many gains, however, have been scored in new fields or in new brands in old fields.

Chart 7 illustrates the strong expansion and increased use of glass containers in the household and industrial field.

While it is the smallest of the four major glass container end use classifications, sales of bottles for packaging chemicals in 1958 comprised 11,459,000 gross (1,650,096,000 units)—or 8.2 per cent of the domestic glass container output (Chart 7). Further postwar gains in this field have been exceeded only by those in glass containers for foods which head the industry list of end uses.

The number of chemicals now packaged for home and industrial use (no breakdown of the two is available) is a long one. Further, the chemical industry has expanded more rapidly than almost any other in the United States, and indications are that it will continue to do so, thereby providing a broadening market for glass containers.

Many products in this field are chemically incompatible with other containers, and a glass package is therefore mandatory. Unlike other products, chemicals are often kept over a long period of time, and the protective properties of glass are a major consideration. Many are volatile, and the tight reseal provided by glass is equally important. And, for both household and industrial use, the visibility afforded by glass—allowing instant check of contents—constitutes a valuable plus for glass.

Among the household chemicals packed in glass are ammonia, bleach, ink, insecticide, furniture and silver polishes, radiator compounds, and the like. Industrial chemicals packed in glass include acids, dyes, glues, reagents and solvents.

Almost all of the 42 companies engaged in the manufacture of glass containers produce many different styles of wide-mouth and narrow-neck glass containers, which are used to package a diversity of products.

Glass Aerosols

The aerosol industry is 14 years old this year and, since its introduction to the general public in 1945, has announced a steady progression of improvements and new developments.

Because this system produces a fine atomization of product at pressures of the low order of 15 psig., and even lower, the introduction of the ultra-low pressure system has made it safe and practical to package alcohol-based aerosol products in glass and other frangible containers. With careful control of the proportions of alcohol, water, and propellent, it is possible to produce a spray of almost any desired degree of fineness with the use of spray-heads.

Data have been reported on low-pressure solvent-propellent systems compatible with basic formulations of aerosol colognes for packaging in glass containers. These data include pressure, spray-characteristics, solubility, and, to a limited extent, flammability.

The solvent-propellent systems studied include varying alcohol-water mixtures with the 2-propellent solutions:

1. Freon-12 dichlorodifluoromethane—Freon-11 trichloromonofluoromethane.
2. Freon-12—Freon-114 dichlorotetrafluorethane.

New Aerosol Processes

In 1947, when the commercial aerosol business was born fewer than one-half million pressurized packages were sold. Sales reached 34 million pressurized packages in 1951; 131 million in 1953; and exceeded 250 million in 1956.

A new development of Connecticut Chemical Research Corporation, known as the Polysol process, promises to improve aerosol packaging. Under this system, propellents can be non-refrigerant gases used singly, in combination with each other, or in combination with refrigerant gases. With new types of valves, and new processing methods for producing areosols, the scope of the pressurized package is ever increasing.

Some of the propellents investigated include helium, argon, krypton, carbon dioxide, nitrous oxide, butane, and propane.

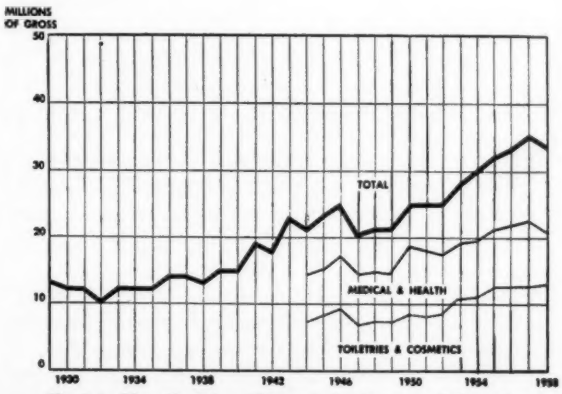

Chart 6. Glass Container Shipments for Drugs and Cosmetics.

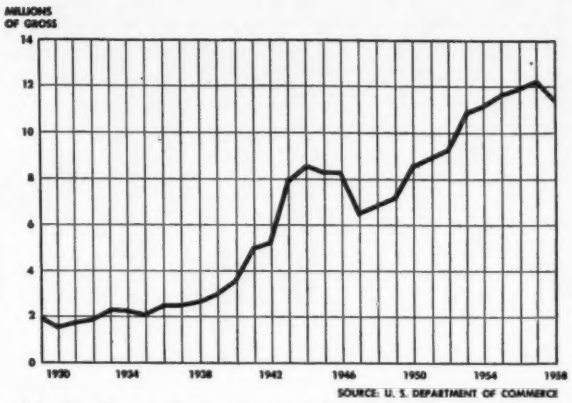

Chart 7. Glass Container Shipments for Chemicals: Household and Industrial.

Glass has a definite advantage over other aerosol packaging materials in regard to chemical products, including drugs and cosmetics. Glass is inert to almost all chemicals and therefore does not require the compatibility tests which other package materials must undergo with newly developed formulations.

The Aerosol Bottle

The increased demand for aerosol packaging in foam, spray, or even dry products (cloud version), may have considerable influence on the glass container industry. Among aerosol products today are hair preparations (particularly lacquers, shampoos, dyes), shaving cream, suntan preparations, foot sprays, hand lotions, deodorants, anti-perspirants, depilatories, colognes and perfumes, nail polish, soap, toothpaste, mouth sprays, and body powder.

Glass aerosol packaging of cosmetic products offers several advantages.

1. No corrosion problem.
2. Greater individuality in container design.
3. Customer habit of purchasing glass-packaged cosmetics.

Silicones for the Glass Industry

Several companies recently announced the successful application of silicone coatings in the container industry. Silicones, basically related to the polymeric family composed of carbon, silicon and oxygen, are man-made; they do not occur naturally. Essentially they provide lubricity and release functions, as well as durability and water repellency. Silicone solutions appear both as aqueous and oil emulsions.

For mold release work, water-base lubricants are the more desirable because the water acts as a coolant. The silicones do not decompose or leave undesirable residues; the molds therefore remain clean for a longer time; and dirt, smoke, and fire hazards are reduced.

Satisfactory results have been achieved when these solutions have been used as coatings for shears, delivery equipment, and mold plates. Carbon deposits have been eliminated and score-marks on gobs reduced. The occurrence of water-hardness scum has also been eliminated.

When applied at the right stage in the annealing lehr, a coating of silicone material will provide a protective, lubricating film that will minimize seizure and scratches;

(*Continued on page* 661)

TEN Years of Progress in the Glass Industry

FIBER GLASS

● THE FIBER GLASS INDUSTRY has shown remarkable development and expansion since its inception in the early '30's and today serves as a major basic raw material for many other products.

Like other synthetic fibers, fiber glass shows certain advantages over natural fibers in its relative inertness, excellent durability, and the fact that it is not likely to corrode or rot. The major developments in the past decade have placed this industry in a commanding position, along with other glass products.

Glass and plastics make a good team. In fibrous form, glass is said to have the greatest strength for its weight of any commercial material. The finest glass filaments have a tensile strength of over 2 million pounds per square inch; steel piano wire rates only 320,000 pounds per square inch. Plastics, reinforced with fibrous glass, can be molded into intricate shapes which would require expensive machining if done in metal.

Each year reveals a constant increase in the variety and versatility of glass fiber products.

The use of glass fibers in the form of batts, blankets, boards, bulk fibers or shredded fibers for insulation purposes continues to grow, for example, as insulation in homes, refrigerators, food and beverage containers, roasters, stoves, and water heaters; freight and passenger planes, railroad cars, trucks, buses, and merchant ships; and factories and other types of industrial and commercial buildings, and their equipment.

The unusual combination of properties possessed by glass fiber products has led to their application in several areas of medicine. In addition to other properties, they are non-toxic, non-allergenic and produce no harmful effect on human tissue. They are easily sterilized and re-sterilized. The usual forms are X-ray transparent, but a special type is radio-opaque, or detectable by X-ray.

In the form of a surgical bandage, the fiber glass is immersed in a setting solution just before it is applied to the wound, causing it to harden into a rigid cast.

Plastic foot appliances, burn dressings, surgical packs for prevention of post-operative adhesions, surgical wound dressings, and tracer threads of special radio-opaque glass are further examples. Future materials include root canal filling, pharmaceutical wadding, and penicillin aerosol therapy are all examples of most recent medical aids.

A major accomplishment in fiber glass which has grown out of experiments conducted over a period of several years, is the development of a new forming process capable of high-speed production of wool products possessing improved insulating values, lighter weight, and better handling properties.

This material is now being produced for residential building insulation in roll blankets and batt forms. Improved insulations for the transportation and appliance markets have also been made by this advanced process, and as experience is gained, the advantages may be applied to materials for other uses.

Another significant process development applied after several years of experimentation was a redesign of continuous textile filament forming equipment to produce strands having double the number of filaments, each of finer diameter, thus upgrading yarns for draperies and curtains. This is a new form of marketing bulked-up for decorative fabrics. It promises to broaden further textures and styles of glass fiber fabrics which may be created.

During recent years, improved finishes have been made available to fabric converters for applying to casement curtains and draperies, in order to create resistance to soiling and sun fading; and to sheer marquisette curtains for greater whiteness. Lower cost methods of roller-printing glass fabrics have also been developed.

New products include a mat-faced ceiling board that has won rapid market recognition and wide usage in supermarkets, schools, public, and commercial buildings. Development of a new type of dust-catching air filtration product increases the range of glass fiber products for these uses. Also being field tested is a frameless filter for window air-conditioning units, designed for ease of replacement and disposal.

Product improvements in temperature characteristics, impact and tensile strengths, and handling properties have been made on pipe coverings and other industrial materials, roof insulating and form boards, and corrosion protective mats.

Products of fiber glass are formed from glass which has been drawn into thin filaments of various diameters, some as fine as 1/300 the thickness of a human hair.

The many desirable properties of glass are retained in that the fibers of glass are incombustible, moisture

resistant, durable, and dimensionally stable. In addition, glass in fiber form can be flexible, resilient, and can have excellent thermal and acoustical properties.

This decade will be remembered for the extensive expansion in fiber glass in which all major companies in the field have taken part. The total volume of business for the year 1958 was about $200 million; it is predicted that by 1960, the industry will have a total volume of $250 million.

Glass Reinforced Plastics

There are many types of reinforced plastics in which glass, cotton, rayon, nylon, asbestos, and paper serve as the reinforcing material. *Reinforcements may be cloth or merely random fibers.*

Thermosetting phenolic, melamine, silicone, epoxy and polyester resins are used. Most widely used are phenolics and melamines, press molded at relatively high pressures into the so-called high-pressure laminates.

Another type is molded under low pressures (about 300 psi or less) or no pressure at all. Low-pressure laminates are mainly polyesters, although silicone, phenolic, and epoxy plastics have been used. Paper, cotton, and other materials have been tried, but glass fiber and fabric are the usual reinforcements in low-pressure laminates.

Tanks, pipes, hoods, and ducts are made of these reinforced materials. The combination of corrosion resistance and strength is the prime advantage. Pressures contained cannot be very high, unless some seepage through the pores can be tolerated. Applications have been made in processing and electroplating in chemical, paper, textile, metal finishing, and allied industries. Large duct systems carry away fumes from automatic pickling and phosphating machines. A recent job included 500-gallon tanks and necessary pipe and fittings for a laboratory waste system. Truck water tanks have been successful, with light-weight and rust resistance the big advantages. Crude oil tanks, bolted together in sections, resist hydrogen sulfide, salt water, and electrolytic action. If, however, the equipment must be cleaned thoroughly and requires an enamel smooth surface, glass-plastic cannot be used, for its surface retains dirt.

Trays and tote boxes made of reinformed plastics are light, strong, and chemically resistant. They are easy to make but cost more than similar metal products. In some cases, glass plastic has not been durable enough. Deep trays, for example, were made too thick and lacked resiliency so that they broke in hard usage. Thinner walls and metal wire reinforcement at the top edges may be the remedy. Materials handling trays for bakery trucks are made in quantity, as well as pans and trays for water evaporation and chemical handling.

New concepts in automobile safety and comfort stimulated trial usage of glass fiber products for instrument panel pads, sun visors, sound absorbing, and temperature control insulation.

Glass Fiber Draperies

A white pigment, 100 per cent opaque, is the basis of a technique to control light. This pigment is added to translucent pigment colors (pigments, not dyes are used to print glass fibers) in varying amounts depending on the degree of opacity desired in the printed design. The pigment will control the amount of light that bounces off the surface of the highly reflective glass fibers; it will also control, or stop, the amount of light that passes through the cloth, because glass fiber cloth is translucent whether it is a sheer net or a thick close weave.

Glass Fibers for Noise Control

Glass fiber noise control products possess all the advantages essential to good sound control installations. They trap noise in the millions of tiny, dead air cells formed by the maze of glass fibers. They reduce danger of ceiling failure owing to warping, buckling, expansion, or contraction of tile and are one of the lightest weight inorganic-type, fire-safe acoustical materials available.

All fiber glass tile and board products weigh less than 1 pound per square foot, an added security in application, especially where adhesives are used.

In addition to acoustical properties, these products afford excellent thermal insulation. The k-factor of the basic material used in acoustical tile and ceiling board is 0.24 Btu per hour per square foot per inch of thickness per °F. at 75° F. mean temperature.

Numerous installations in hospitals and other critical areas have demonstrated that they will not absorb or give off odors; they will not rot or decay, and they offer no sustenance for bacteria, termites or vermin.

Glass fiber noise control products should not be applied against or below surfaces which are subject to frequent condensation; in areas of constant high humidity; or under conditions which will cause acoustical materials to remain wet.

The fiber glass products should not be used in areas subject to physical abuse; nor is it advisable to install them with nails or screws. They should not be used where continuous or intermittent temperatures exceed 150° F. or where extreme variations in relative humidities are expected.

Glass Fiber Insect Screens

A new glass fiber screen is said to combine outstanding resistance to rust, corrosion, and weathering; it has the advantages of fire safety, permanent color, and high-impact strength and shows virtually no shrinkage or stretching under temperature extremes or excessive moisture. The new screen is woven of vinyl-coated fiber yarns.

Paper Reinforcements

Fiber glass yarns are now being used to a greater extent for fibers in industrial paper and tape reinforcement. They offer great strength, light weight, dimensional stability, resistance to breakdown from heat and cold, and resistance to moisture and rot. They are stronger in equivalent diameter than cotton, jute, or rayon yarns.

It is possible to design and manufacture reinforced papers and tapes which have comparable or greater strength but are generally lighter and less bulky than those fortified with other materials.

A wide variety of products is possible such as heavy-duty pressure tape, wrappings for pipe and steel rods, carton sealing tapes, corrugated box tapes, crate and box

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TEN Years of Progress in the Glass Industry

FLAT AND STRUCTURAL GLASS

● PRIOR TO 1954 DOMESTIC USE OF window glass was about 3½ square feet per person and plate glass, about one square foot. Beginning with 1954, window glass was used at the rate of 10 square feet per person and plate, at about 3½ square feet. And glass in architecture is still increasing today.

Window areas have expanded and are now glazed with both plate and sheet. Not only has the size of exterior wall openings increased tremendously, but the modern homeowner is insisting upon the use of double-glazed insulating units for both windows and window walls. This means twice as much glass, and special installation. Then there are jalousie doors and windows and for full wall treatment, sliding glass doors of many styles.

Much work has also been done in the past year in developing new mass production methods for making glass seals that are adaptable to the manufacture of insulated glass units. These are expected to be used increasingly in moderately priced homes, factories and other structures where heat control and comfort are essential factors.

Architects, engineers, and structural designers are considering the use of glass in curtain wall construction, especially in offices, schools, and public buildings. Glass spandrels have been enhanced both by improvements in glazing techniques and extensive research in heat and light transmission through glass. One spandrel type is a rolled, patterned glass with a textured surface on the weathering side. A ceramic enamel is fused to the back to impart the desired color. A coating of atomized aluminum is also fused to the back to protect the colored enamel and reflect heat.

Spandrelite provides a hard, non-porous polished surface which resists most atmospheric acids and temperature changes. It will not fade, swell, warp, craze, or deteriorate; it is easy to keep clean; retains its original color and polished appearance; and can join with large areas of plate glass walls to provide interesting reflection patterns.

The heat-strengthening process, fusing the ceramic color to the plate base, gives the entire structure far greater shock resistance than ordinary plate glass of the same thickness.

In addition to custom colors, ranging from pastels to dark tones, and textures from polished to tapestry, many standard colors have been provided in a choice of polished plate glass or opaque finishes. Special designs, insignia trademarks, plaid, spatter, and mottled patterns are also possible as well as metallic and iridescent effects.

In building construction, the color side is mounted to the interior, providing additional weather protection of a quarter inch or more of glass. The product is non-porous, self-cleaning, non-absorbent and stain- and-odor proof.

Flat Glass in 1957

Flat glass production, in 1957, was about 10 per cent less than that of 1956, due, in part, to a somewhat leaner automobile market. The decline was primarily caused by the heavy imports of plate and window glass.

As a result of the cut in U. S. tariff from 1.55 cents per pound in 1946 to 0.72 cents per pound at present, window glass imports amounting to a few hundred boxes in 1946, zoomed to 3,500,000 boxes (50 square feet per box) in 1958.

This influx is estimated at more than 10 per cent of the domestic window glass capacity. Plate glass was also imported heavily over the same period.

It is significant to note that the selling price of window glass today is only 59 per cent above that in 1926. Plate glass prices are actually 2 per cent below those of 31 years ago, whereas during the same period building materials as a whole have advanced 151 per cent, and the average hourly straight-time earnings for employees have increased 450 per cent. To have achieved such results it is obvious that great strides have been made in manufacturing techniques and efficiency.

The automobile industry continues to be a big customer for flat glass and the area of glass used per car is constantly increasing. Harold M. Alexander, General Manager of Development and Research, Libbey-Owens-Ford, commented on an exhibit containing representative windshields and backlights for various models of cars between 1937 and 1957. He pointed out that the 1957 Chevrolet curved backlight is more than three times the area of the corresponding flat part in 1937 and that the 1957 Buick backlight is 50 per cent larger than its 1948 counterpart. The 1937 Cadillac flat windshield was 6.4

square feet in area, as compared with an area of over 14 square feet in the windshield of the 1957 Cadillac Eldorado. The Eldorado windshield is curved not only on the sides, but also along the top to blend into the roof lines. The use of curved parts and greater glass areas has made a very important contribution to safety through reduction of blind spots for the automobile driver and has been an outstanding factor in improving automotive appearance and styling.

The building industry is continuing the trend toward the use of curtain walls in large structures, and glass is being recognized as an economical, useful material for these walls.

A new twin-ground, neutral grey polished plate glass, recently put on the market, is especially useful in curtain wall construction where reduction of glare is desirable, along with transmission of true colors. It is a heat-absorbing glass, useful in connection with air-conditioning systems. This new glass is made in 1/4" thickness with maximum standard sizes of 90" x 120". It reduces transmission of average daylight to 40 per cent, and transmits 45 per cent of the total sun energy or heat, while the ultraviolet transmission is 39 per cent.

Rough plate glass blanks in large sheets were marketed primarily for use as interior partitions where good light transmission is desirable along with obscurity. These sheets are 21/64" in thickness with a maximum size of 100" x 144". They may be of regular or heat-absorbing type glass.

Another development in 1957 was the improvement of insulating glass using a metal-to-glass bond to seal hermetically the dry air in the space between multiple panes. Although more than 7,500,000 units are now in use, much study has gone into suggested improvements. Exhaustive tests have shown that units of fabricated glass with clean-cut edges are less susceptible to breakage than when edges are ground, so that all units will be fabricated with clean-cut edges. To protect installation and handling of such edges, they will be enclosed in an aluminum channel attached with a continuous bead of special mastic which will also absorb reasonable impacts on the frame. It is claimed that damage to corners or edge chipping in warehousing or glazing will be greatly minimized by the new type of edge framing.

Full scale production of heat-strengthened glass building panels was begun at the Ford City, Pennsylvania plant of Pittsburgh Plate Glass Company.

The new horizontal assembly line is a continuous operation whereby plate glass goes through a wash and dry cycle, then continues through a booth where ceramic color is automatically sprayed. Next the glass rolls on a conveyor through the furnace for fusing the enamel and strengthening, all in one operation.

Custom colors can be provided and designs may be silk screened in either one or a number of colors if desired. The product can also be manufactured with ceramic color on part of the glass with the remainder transparent.

The largest single use of spandrel glass, about 100,000 square feet, has been the new Arrivals Building at Idlewild Airport, New York.

Double-glazed insulating glass units in sizes up to 50 square feet, were made available in 1957 in which many important architectural advantages were incorporated: a near-black mirror-like outdoor appearance permitting additional architectural design emphasis on the fenestration pattern; the color-free neutral light transmitting properties of the unit which remove interior decorating restrictions on carpeting, wall and drapery colors; low (37 per cent) visible light transmission, reducing noticeability of ventian blind and drapery positions from the exterior, enhancing the building appearance from outside; better glare control for greater visual comfort without shades providing better visibility and, from a design point of view, a more complete indoor-outdoor integration.

The tendency of color fading is decreased because of lower visible light transmission.

Production and shipments of the various types of flat glass for the years 1957 and 1958 are shown in Table I.

TABLE I
FLAT GLASS: PRODUCTION AND SHIPMENTS
1957-1958

Type	1957 Value ($1,000)	1958 Value ($1,000)
Flat Glass		
Total	216,583	189,019
Sheet (window) Glass (not rolled) including colored		
Total	106,947	92,339
Uncolored: Thin including picture glass		
Total	1,770	1,460
Single strength		
Total	44,743	38,144
Double strength including greenhouse		
Total	33,625	26,046
Heavy Sheet		
Total	26,809	21,262
Tinted or colored (all thicknesses)		
Total	.....	5,427
Plate and other Flat Glass		
Total	109,636	96,680

Flat Glass Trends in 1958

Flat glass sales during the first half of 1958 were down about 22 per cent from 1957, owing to reduced requirements in the building and automotive fields. The third quarter of the year showed a reversal of sales trend in August and September.

The fourth quarter, which was expected to bring back the total volume for 1958 to a fairly good year, was harassed by strikes. It was a disappointing year.

Another discouraging trend in the industry has been the impact of foreign competition, especially on coastal areas. The renewal by Congress of the Trade Agreement Act permitting still further reductions in tariff promises to depress the industry even further. It is felt that increases in the demands of both the building and automotive industries, coupled with the improved ability of the industry to produce, will create greater business activity in the years ahead.

The year 1958 was distinguished by plant improve-

ments either in the form of new plants and equipment or rehabilitation of older ones.

TABLE II

VALUES OF GLASS PRODUCTS SHIPPED ($1,000)*

Year	Flat Glass	Sheet (Window) Glass	Plate Glass and Other Flat Glass	Pressed & Blown Glass Except Glass Containers
1947	196,703	72,525	124,178	233,099
1949	.....	.....	.....	242,418
1950	.....	.....	.....	324,696
1951	248,781	97,880	150,901	324,939
1952	231,508	88,375	143,133	324,599
1953	268,231	104,989	163,242	361,865
1954	263,048	99,124	163,924	416,997
1955	336,445	124,552	211,893	452,163
1956	(S)	127,900	(S)	483,841
1957	(S)	(S)	(S)	494,938

(S) Withheld because the estimate did not meet publication standards, either on the basis of the associated standard error of estimate or on the basis of a consistency review.

* From Bureau of Census, U.S. Department of Commerce.

Cumberland, Maryland Plant (Pittsburgh Plate Glass Company) is located along the Potomac River about six miles below Cumberland, Maryland. This plant is geared to produce polished plate glass for use principally by furniture and mirror manufacturers and the construction industry. Production capacity is estimated at 50,000,000 square feet of polished plate glass a year.

Its continuous production line includes many advanced scientific and engineering developments which mark a new era in plate glass manufacturing technology. From the automatic weighing and mixing of raw materials to the intricate cutting and packing lines, especially designed automatic equipment plays an important role in maintaining highest quality production. This advanced technology and "Pittsburgh's" 75 years of glass making experience are combined to assure maximum efficiency in the high-speed production of plate glass.

From the cooling area the continuous glass ribbon enters a battery of giant twin-grinders which incorporate the most advanced plate glass grinding techniques. In these, both surfaces of the glass ribbon are precision ground at the same time to give the glass maximum optical quality. The grinding heads are 11 feet in diameter and weigh approximately 8,000 pounds. The grinding material is specially processed silica sand.

A complicated grading system separates the sand into 14 different sizes for feeding to the grinding units. In the first units, sand particles are about 24 thousandths of an inch in diameter; in the last one they are less than the size of pinpoints. After being perfectly ground, the glass is automatically cut into plates 15 feet long, which then move on a conveyor to the polishing lines.

The polishing system at this plant includes many innovations which are designed to increase speeds appreciably. Operations begin by transferring the ground plates from the conveyor to an endless moving line made up of cast iron "tables" covered with a cloth that holds the plates firmly in place. These "tables" move under a series of polishing bridges, each having nine rotating blocks which use a solution of water and rouge to polish the ground glass to a transparent finish.

After one side is polished and washed, a vacuum crane lifts the plate to a conveyor which moves it to a "barrel" turnover. This automatically receives the glass, reverses it, and sends it to the second polishing line where the other side is processed. All operations are continuous.

Some of the production of the plant will be processed by mirror manufacturers or fabricated into double-glazed picture windows. A portion of the glass will be processed at other company plants into special glass products such as protective screens in factories and sports arenas, electrically conductive glass for windshields for aircraft, ships, and trains and for many other applications.

Glass Research Center, Harmarville, Pa. (Pittsburgh Plate Glass Co.). Opened in the spring of 1958. The development and product control building, first of the two structures to be erected, has an area of 170,000 square feet and is designed with a high bay for accommodating pilot plant equipment and providing ventilation over high-temperature areas such as tanks and furnaces. It has an area 480 feet by 260 feet and possesses movable partitions in the shop locations.

A single-story structure, the development and control building includes a mezzanine floor for offices and laboratories. The basic research building will be a glass-clad structure of six floors with 70,000 square feet of floor space. This structure will contain chemical, physical, and analytical laboratories, plus administrative offices and a library. It also features movable partitions and has a connecting passageway to the development building.

Crestline, Ohio Plant (Pittsburgh Plate Glass Co.). A multi-million-dollar glass fabricating plant on a 49-acre site at Crestline, Ohio. The factory consists of 275,000 square feet of floor space, one story, with glass and pre-cast concrete walls. Much of the equipment has been developed by the glass division's research laboratories and engineering department. Crestline was selected for the plant location because it is between the source of glass supply at Mt. Vernon, Ohio, and major automotive customers.

Executive Office Building (Libbey-Owens-Ford). Dramatizing the company's flat glass products, the building's four walls are entirely encased in glass, framed by aluminum. Thermopane insulating windows unusually large, approximately 6 feet wide and 10 feet high, and spandrels of Vitrolux, a heat-strengthened glass with vitreous color firefused on the back surface for permanence are used. The building is fully air conditioned, with luminous ceilings, movable partitions, and vertical blinds for light control. Floors will have vinyl plastic coverings. The ground floor will be entirely devoted to lobby, telephone exchange, and five high-speed elevators. The two top floors will be given over to mechanical equipment, chiefly the air conditioning system and network of ducts.

Glass and the United Nations

The United Nations headquarters, opened officially in New York City in 1952, is an international monument to glass. Five years in the planning and building, and costing more than $67 million, the UN group consists of three buildings: the Secretariat, a towering structure of 39 stories; the long squat Conference Building; and the General Assembly Building, keystone of the entire group.

Photosensitive glass is used extensively in the General Assembly Building as a structural material. Its color and design blends perfectly with the giant slabs of Vermont marble to form the north facade. Because the entrance to the General Assembly is considered the most impressive in the entire UN group, photosensitive glass panels are in the most advantageous position. They are not translucent and are cemented to their regular cinderblock walls. The panels in the General Assembly Building are glazed (the first time for this operation) with photosensitive glass and also admit light. They are adaptable in almost any design.

Heavy Windows

Heavy window glass, formerly considered a rather expensive structural material, is now being used in low-cost housing. Window walls, making up 16 to 20 per cent of the total area, have been shown to reduce costs in certain regions of the Southwest.

An attractive feature of these windows is their ability to extend the living space outdoors, beyond the physical boundaries of the house. Vigorous national advertising is underway to emphasize how glass may beautify the home in the form of polished plate, mirrors, block, and decorated fenestrations.

Sheet glass is also available in large sizes (110 by 200 in.) which will exclude more than 99 per cent of the ultraviolet rays of the sunlight, without noticeably impairing the visible transmitted light. This glass is useful in store fronts (prevents fading), in museums (display of valuable documents), and in television protective screens. The insulated window pane has been widely accepted in modern railroad passenger coaches and buses.

Luminous Electric Windows

What will the windows in the homes of 1975 be like? Researchers are continuing their work on glass which "conducts" electricity, grows warm and radiates heat at the touch of a switch or glows with softly diffused light in a variety of colors. This glass was developed for use in aircraft during World War II and is now widely used as windshields in aircraft and on the bridges of ships to ensure maximum visibility by preventing the formation of ice or mist. A minute film of transparent metallic oxide on the surface of the glass is the secret of this glass' ability to "conduct" electricity. This film is 15 to 20 millionths of an inch thick.

The film is as durable as the surface of the glass and can be cleaned just like any other window. The glass itself is semitempered during the application of the film and is therefore tougher than regular glass. When an electric current flows through the metallic film, the glass grows warm and radiates heat. The intensity of the heat can be turned all the way up to 450° F without endangering the glass.

Such windows become a lighting fixture through "electroluminescence." This is achieved by another minute film of various phosphors. So far scientists have developed films which glow with blue-green, green, and yellow light; they are working on a phosphor to produce red which, when found, will enable them to make windows glow with almost any desired color.

The glass will be heat-tempered, twin-ground plate, so distortionless that from indoors the grass and trees outside will seem to be a part of the room. When the sun sets, a simple turn of a thermostatic switch will make the glass become warm, warming the room with radiant heat and preventing the windows from frosting or collecting condensation.

Corrugated Glass

A decorative glass combining two popular decorating features, corrugation and a light-diffusing patterned surface is ⅜ inch thick with corrugations 2½ inches center-to-center. The pattern, rolled onto the surface of the glass as it is made, has a textured, neutral tone that blends with any decorating scheme. Since the pattern on corrugated glass is the same as that on certain tempered patterned glass doors, the former can be used in combination with doors, to make an attractive, translucent wall. The corrugated glass is ideal for room partitions, room dividers, exterior entrance-way wind-breaks, and other applications requiring privacy without excluding light.

Tempered Glass

A new tempered glass, which may be permanently decorated for use in all-glass doors and store front applications, is ½ inch thick and weighs 50 pounds less than the same size ¾ inch tempered door formerly available.

Some advantages of the newer glass are:

1. It will not solarize; that is, it will not run an amber shade when exposed to sunlight.
2. Reduces glare.
3. Reduces the iridescent effect sometimes noticeable on tempered glass under certain lighting conditions.
4. More compatible with the greenish tint of heat-absorbing glass and makes a better match on this type of installation.

This tempered glass offers an almost limitless range of design possibilities; it can be decorated by permanent, fired-on, true ceramic colors or by sandblasting.

Electrically Fused Double-Glazed Glass

About 1953, the manufacture of the first all-glass double-glazed insulating window was started. The edges are electrically fused to provide a glass-to-glass seal having no metals, bonding materials, or other assembled parts in its construction.

Insulated glazing now makes it possible to use all-glass walls. Heat transfer properties are the same as for the assembled insulating windows previously manufactured (metal-to-glass).

Under average conditions the glass walls will reduce the amount of heat transfer by about one-half the normal amount transferred through an equivalent area of conventional single-glazed windows. This factor is a year-around attribute in that heat loss is reduced during the season when heating costs are a consideration, and heat gain is reduced during the warm-weather period.

Constituting one of the most effective thermal insulating units yet developed, these glass walls also reduce condensation problems and offer greater seeability by reducing the tendency for inside glass fogging during the winter months. With the increased use of air conditioning in homes and the trend to insulated window

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TEN Years of Progress in the Glass Industry

ELECTRONICS INDUSTRY

● THE ELECTRONICS INDUSTRY, founded on the de Forest triode vacuum tube in 1906, emerged during the early 1920's with the advent of radio. Today, it is the fifth largest manufacturing group in the United States.

During 1958, some 1,500 equipment suppliers and major assemblers, 2,400 component manufacturers and 700 producers of switches, wire and other electronic hardware established a new aggregate sales record of $7.9 billion. When distribution, servicing and broadcasting revenues are added, the total is $13.3 billion.

The size and growth of electronics manufacturing is measured in terms of four market areas—consumer, industrial, military and components replacement. Each of these had grown steadily prior to 1958 when the recession adversely affected the consumer and replacement markets; however, increased sales of military and industrial products off-set these declines to raise total factory billing by $140 million.

Tubes

Sales of receiving tubes, one of the more important components of electronic nerve centers, attained a unit total of 397 million in 1958 with a value at the manufacturer's level of $342 million (see tables). This compares to the previous year's billing of 456 million units valued at $384 million. The export market continued to expand. Sales directly to the Government also increased from less than eight million units during 1957 to thirteen million units in 1958.

Technical improvements in both picture tubes and receiving tubes are continuing unabated. Developments in the TV tube are tending toward shorter "necks," more efficient electron guns and improved picture quality. The "cold" cathode receiving tube is now nearing the production state. This tube contains no beater supply or filament; consequently, a major source of tube failure is eliminated.

MANUFACTURERS' SALES OF PICTURE TUBES BY SCREEN SIZE*

	1948	1949	1950	1951	1952
15" and Under	1,145,583	3,316,767	2,365,380	437,148	296,753
16" thru 18"	9,123	179,682	5,356,102	3,586,976	3,004,786
19" thru 21"			211,940	973,233	4,296,735
22" thru 25"				120,739	30,409
26" and Over					
Projection	154,470	16,601	23,645	17,703	6,983

	1953	1954	1955	1956	1957
15" and Under	267,380	235,954	412,226	1,595,940	517,598
16" thru 18"	3,065,102	2,086,077	1,805,081	1,908,933	2,231,449
19" thru 21"	6,105,068	7,223,259	7,764,175	6,713,446	6,414,945
22" thru 25"	275,504	318,665	948,104	741,512	534,570
26" and Over	119,964	286,925	34,648	27,190	22,446
Projection	6,120	2,624	†	†	†

	1958
15" and Under	289,149
16" thru 18"	2,063,900
19" thru 21"	5,511,011
22" thru 25"	370,982
26" and Over	17,438
Projection	†

* Made from new glass
† Included with 15" and under

Glass Screens

Automatically produced glass screens with 562,500 precisely etched holes per square inch are now available. With excellent dielectric properties, the screens are particularly suitable for electronic storage tubes and for targets in image orthicon tubes. Transmission of these screens can be as low as 40 per cent or as high as 70 per cent, depending on width of the holes. These range from 0.00085 inch to 0.00112 inch.

The new screens are made of Fotoform, a strong chemically etchable photosensitive glass. With an etching ratio 15 times higher than that of conventional glasses, the material can be chemically machined in a screen pattern with submicroscopic, square-cornered holes, each of which is less than half the diameter of a human hair. Thickness of the circular screens after etching is 0.003-0.005 inch. Largest size now available is 1.750 inches in diameter with a screen diameter of 1.500 inches.

New Type Television Tubes

Through the development of a new method of glass lamination, Corning Glass Works has introduced a shatterproof dust-free contoured twin panel television tube. The tube consists of a second contoured glass-face panel laminated permanently to the original bulb, eliminating the need for the present front safety plate. The twin panel tube, after lamination, is as shatterproof as a modern automobile windshield, and the two inside glass surfaces are dust-free for life.

Two new laminating materials were developed, one by Rohm & Hass Company, the other by Dow Chemical Company, to make the new process possible. Each of the two substances have the same refractive index as the tube glass and panel glass. The process consists of simply casting a liquid plastic between the surfaces to be laminated. No pressure is required, and only moderate heat. The new laminating materials do not require the use of special mountings or gaskets.

Pittsburgh Plate Glass Company has also developed a new type of TV tube with built-in safety, which makes it possible to eliminate the present separate front window now standard on all TV sets.

This particular laminated safety tube is said to provide a picture brightness improvement of from eight to nine per cent, improving the contrast between light and dark parts of the picture. It also eliminates objectionable reflections from both surfaces of the present window and also lessens glare.

Instead of the present outside safety glass window, the new tube has a lightweight one that is curved to fit the tube face and acid-etched to provide the satin finish laminated directly to the face of the picture tube by means of a layer of Selectron polyester resin.

Several major manufacturers are studying the feasibility of producing the new unit tube and are engineering for pilot plant production: the tube may reach the public in TV receivers coming on the market in mid-1959.

New Products and Developments

Research in the field has been confined largely to emphasis on methods of reducing halation and specular reflection. These methods have involved tinted, etched, and cylindrically curved face plates. A very considerable

MANUFACTURERS' SALES OF PICTURE TUBES BY END USE*

Year	Initial	Renewal	Export	Government	Total	Value
1948					1,309,176	$ 33,459,554
1949	3,305,673	202,663	4,459	255	3,513,050	98,136,591
1950	7,473,614	472,261	11,184	8	7,957,607	210,714,743
1951	4,434,126	674,284	21,343	6,046	5,135,799	122,224,186
1952	6,120,292	1,431,952	83,372	50	7,635,666	170,652,079
1953	7,583,225	1,800,185	451,476	4,252	9,839,138	234,861,041
1954	7,514,691	1,808,324	590,051	438	9,913,504	206,075,994
1955	7,751,853	2,360,813	760,680	888	10,874,234	209,007,518
1956	7,539,835	2,725,696	721,416	74	10,987,021	196,220,240
1957	6,174,979	2,779,111	766,676	242	9,721,008	183,231,337
1958	4,954,816	2,503,242	794,199	223	8,252,480	163,482,674

* Made from new glass.

MANUFACTURERS' SALES OF RECEIVING TUBES BY END USE
(000 Omitted)

Year	Initial	Renewal	Export	Government	Total	Value
1945	57,235	40,462	4,995	36,786	139,478	$ 68,500
1946	129,637	65,228	9,991	361	205,217	101,000
1947	131,987	43,530	23,184	833	199,534	107,000
1948	146,162	47,056	10,687	815	204,720	112,000
1949	147,298	39,696	10,073	1,686	198,753	119,000
1950	301,483	69,325	10,768	1,385	382,961	250,000
1951	247,855	94,597	24,438	8,754	375,644	261,000
1952	241,406	83,843	13,935	29,335	368,519	259,116
1953	293,601	112,785	20,614	10,091	437,091	303,675
1954	246,729	115,358	15,922	7,080	385,089	275,999
1955	288,810	150,718	24,442	15,832	479,802	358,110
1956	262,898	166,558	25,397	9,333	464,186	374,186
1957	240,708	184,493	23,378	7,845	456,424	384,402
1958	191,832	167,805	24,597	13,132	397,366	341,929

effort has been devoted to the use of lower-cost metals in the metal-glass tubes, thus involving the development of new glasses and techniques for their sealing.

In general, these developments have been concerned with the use of glasses of higher coefficient of thermal expansion and have been extended to glasses which can be used with unalloyed iron. The preponderant use of rectangularly shaped envelopes has involved the development of techniques of producing glass-metal seals in the presence of stresses resulting from non-symmetrical shapes.

Communication in practically every modern form is dependent on glass, which has contributed in large measures to the birth, growth, and expansion of the entire electronics industry. The reception and service provided by the radio, television, telephone, radar, and other electronic devices would not be possible without glasses that stand up under high power and voltages at even higher frequencies.

Metallized glass components for electronics include assorted temperature-stable inductances and trimmer capacitors, bushings for hermetically sealed enclosures, and other components used in radio and television.

A large radio transmitter tube for example has been developed which operates smoothly and without interruption because glasses will withstand the heat and voltages of modern, high power radio and television transmission.

Television and Radio

The popular acceptance of television has brought increased demands on production in this field, and inasmuch as a considerable number of parts are fabricated of glass, improved methods of manufacture have been demanded. The initial requirements of television were easily met by hand-shop methods; however, it was inevitable that these expensive methods should be replaced by machine operations.

The old process, which consisted of molding glass to blanks and putting them through rigorous optical grinding and polishing operations to obtain spherical perfection, has been replaced by methods whereby meticulous grinding and polishing operations are reduced to a standardized process, completed while the glass is still flat.

A newly developed bending process permits perfect sphericity without marring the precision surface obtained before the blanks are cut to size. This technique has already been applied to the production of 5", 10" and 12" tubes and is expected to be extended to larger tubes. These operations have definitely removed some of the major bottlenecks in tube production.

The new face plates can now be manufactured on a production-line basis with a great reduction in time. Mechanical equipment for checking spherical perfection has been developed, and it is now possible to confine the inspection time to a few seconds for each plate. It should be emphasized that production activity is not handicapped because of the bulk of glass used but because of the many time-consuming precision requirements for producing a flawless picture face glass.

Glass research in the field of television has not been confined to tube manufacture alone. One development is the curved protective or implosion plate used to cover the tube faces. Heat-treated or tempered glass, tailor-made to fit the tube face is proving ideal for this purpose.

Implosion plates are protective both to the television audience and to the tube itself. Improvements have been made in eliminating the tendency of the glass in the high-voltage television tube to turn brown, and thus reduce the light out-put. The development of a special filter to be used in front of tube faces to reduce the loss in contrast or sharpness resulting from excessive room light has been made.

Further contributions of the glass industry to television have been in the improvements of surface mirrors, corrector lenses, spherical reflecting mirrors, and high-expansion glasses for fusion to lower-cost metals. Glasses usable with special alloy metals have also been produced. These metal-glass tubes, because of their light weight, are especially desirable in large direct-vision tube sizes.

New glasses have been developed which increase the sharp black and white contrast picture without dazzling brightness, so that television programs may be viewed equally well in daylight or artifically lighted rooms. These glasses are designed for use in the faces of metal picture tubes and provide contrast ratios, long sought after by television manufacturers as the ideal range for eye-ease and perfection of image reproduction. They are said to provide television pictures equal to black and white photographs.

These glasses act as a filter to reduce the detrimental effects of room light and, at the same time, minimize the halation caused by light formed from internal reflections within the tube face itself.

A new glass for television picture tubes containing no lead and approximately 15 per cent less weight than the former tubes, has been developed. The saving in weight is appreciable; for example, the 16-inch bulb whieh normally weighs 21 pounds will now weigh only 18 pounds in the new glass. The new tube will also be more economically produced. This glass will require no readjustment of present tube making facilities, because its working characteristics and electrical properties are basically the same as those of the old lead glass.

Safety Glass for TV

A new grey-colored safety glass for television cabinet protective windows, designed to meet the needs of larger picture tube manufacture as well as provide exceptional black and white contrast, has been developed. The new flat glass product has carefully controlled color, resulting in a nominal light transmission of 55 per cent. The purpose of the new glass is to enhance the contrast of any picture tube under a wide range of external lighting conditions.

The color is in the glass itself, and not in the plastic interlayer and therefore provides complete uniformity and stability of color. There are no limitations on the kind or thickness of vinyl plastic with which it can be laminated to meet the severest implosion requirements. These windows have been tested both in the laboratory and in the field and have successfully withstood implosion of 30-inch circular metal tubes, 27-inch rectangular tubes (both glass and metal) and 21-inch tubes (both glass and metal). The new television glass has the same grey

color as the plate faces used in picture tubes, thereby eliminating double reflectance. The color sameness also eliminates the possibility of a color conflict between the protective window and the tube face.

Color Television

Of the 530 television stations in operation in 1955, more than 265 were equipped to transmit network color programs. It has been estimated that about 200,000 color receivers were sold during 1955.

The new color tube has a picture area of 250 square inches—nearly 22 per cent more viewing area than that of any other color picture tube now on the market. The retail price of the new color receiver is about $900, and its cost is about equal to the cost of three black-and-white receivers.

In addition to big-screen pictures a new 21-inch kinescope offers such advantages as:

1. Excellent color-picture brightness, contrast, and fidelity which match the picture quality of comparable-size black and white kinescopes.
2. Short tube length which will facilitate the design of compact television cabinets. Despite its increased picture area, the 21-inch color tube is actually shorter in overall length than the 15-inch kinescope.
3. A unique engineering feature of the tube is a curved shadow mask which is principally responsible for the tube's excellent color brightness and fidelity. It can absorb, without distortion, more power input than any other type of mask.

The tube's metallized screen is an array of more than one million small, closely spaced phosphor dots on the inner surface of the tube's filterglass faceplate. The dots are arranged in triangular groups of red, green, and blue. The curved shadow mask, containing more than 350,000 tiny holes, is mounted immediately behind the tube screen, with each hole aligned with a particular trio of dots on the screen. The electron beams produced by the three electron guns of the tube must pass through each of the 350,000 holes in the mask to strike and activate the phosphor dots in each triangular group.

The thermally compensated action of the shadow mask enables it to expand under the bombardment of the electron beam in such a manner that each of the 350,000 holes remains in alignment with its particular trio of red-green-blue dots on the tube screen. This constant alignment assures color purity.

A 22-inch rectangular glass bulb for color television picture tubes is also available. The 22-inch rectangular unit is expected to become a standard for the industry. Besides the advantages of large viewing area and rectangular shape, the bulbs offer the fundamental cost advantage of glass units.

The new tube is approximately the same length and height as a 19-inch round bulb and is designed to fit into the same size cabinet. It is designed for a shadow mask tube and constructed so that the mask can be mounted by either of the 2 methods now in use—the flat land or the pin method. The bulk is adaptable to either the three-gun or single-gun systems, the 2 major systems for color television.

Color television is now bringing the whole industry to a new cycle of growth. The initiative must be taken, as well as a willingness to take great financial risks for pioneering a new development. A major producer in the field is said to have spent $50 million in pioneering black-and-white television to the commercial stage, and an equal amount will be spent on color television before any profits are realized.

Lamp Industry

The lamp industry in the United States produced an estimated 2¼ billion lamps in 1955. Divided by types, this would amount to: Fluorescent, 90,000,000 units; incandescent, largely household sizes, 975,000,000; photographic, 5,000,000; miniature, 380,000,000 and Christmas lamps 295,000,000. The 1955 production volume has an estimated retail value of $700 million.

The electronics industry is an example of peacetime application of many defense and wartime developments. Glass research has aided the industry greatly, and modern developments have not been confined entirely to tube manufacture alone.

Improved protective implosion plates have been used for special filters for the reduction of glare and improvement in visual presentation. It is very interesting to note that the continued growth of television has not reduced the demand for radio sets as was initially feared. Broader use of television equipment in fact, has actually brought about a greater demand for radio and electronic tubes.

Electronic Equipment

Electronic equipment purchased by the military during 1958 accounted for $4.1 billion of the $7.9 billion total (up $200 million from 1957). The value of equipment sold to industrial users registered an $80 million gain over 1957, reaching $1.38 billion.

Sales of replacement parts, tubes and semiconductors declined from $900 million to $860 million. Factory sales of consumer products—TV, radio phonographs, and related electronic household items—totaled $1.6 billion during 1958, down $100 million from 1957.

Electronic technology continues to advance in every field. During 1958, television picture tubes and cabinets were improved in both structure and quality. Transistor radios found greater popularity. Consumers for the first time were able to enjoy stereophonic sound on records.

Closed-circuit TV sales reached new highs during 1958 while incorporating color and portability. More electronic tools for medicine were introduced. Innovations in computer design made the "electronic brains" the forerunners of tomorrow's "thinking machines." Automatic control devices for offices, factories and freight yards scored significant sales gains.

Transistors found countless new applications in such areas as data processing, instrumentation, tape transport systems, medical research and telephone networks. They have proven to be especially important to the complex guidance and communication systems of military aircraft and missiles.

The swift rise of employment in electronics during the past ten years reflects the industry's dynamic growth. Between 1947 and 1956, employment more than doubled, approaching 625,000 workers.

Today, there are some 700,000 persons employed in

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TEN Years of Progress in the Glass Industry

TECHNICAL ADVANCES

● THE ENTIRE GLASS INDUSTRY has been greatly aided by extensive research and development programs. One major producer has indicated that over 75 per cent of its current products were developed by research efforts of the past ten years.

Technical Advances

Many glass-making operations are being made as nearly automatic as possible. Forehearths are commonly equipped with automatic temperature control equipment, and many melting furnaces have automatic glass level gages which control the operation of batch chargers to provide, automatically, a constant level of glass.

Radiation pyrometry is becoming increasingly important, particularly for service at high temperatures.

Other developments in the field have included the use of small unit melters. These melters are used to meet requirements for relatively small quantities of glass, up to 40 tons per day, and for special glasses. They are usually equipped with 1 or 2 feeders, but some are used partly for hand operation. Direct-fired, and of simple, inexpensive construction, the unit melter has proved extremely economical and flexible in operation.

Stirring units, for stirring glass in a forehearth, are applied to many operations. During recent years easier adjustment and more stable operation has been achieved in glass manufacture. Advantage has been found not only in the improvement of the homogeneity of the glass, but also in the decrease of thermal differences in the forehearth.

Bubbling

Interest has grown in a method of stirring glass in the furnace known as "bubbling." A small volume of compressed air is introduced through multiple openings in the bottom of the furnace. The reports indicate improved quality of glass, although there have been no published results.

Changing the color of glass by addition of coloring materials to one forehearth of a furnace has been a subject of considerable interest. Little is known regarding the extent or success of the various methods proposed or actually used. It is understood that the color change is limited for most practical uses to changing or modifying the color of flint glass so as to produce a light green or light blue product.

There have been no major advances in feeding, forming, conveying, or annealing of glass, although there have been the expected refinements of process and equipment, resulting in increased efficiency of operation.

Improved Melting Technique

Large regenerative furnaces showed increased efficiency and longer life during 1958. One furnace completed a campaign of a little more than five years at an average fuel consumption, equivalent to about six million BTU per ton, or nearly twenty-five per cent below the usually accepted fuel consumption. This furnace is not unique but does represent modern design, good application of refractories, and excellent control of operating conditions.

Direct-Fired Unit Melters

The small direct-fired, glass melting furnaces known as Unit Melters have continued to be used for additional melting capacity, for special colors or composition, and for small plants located close to the packing house or bottler. As of 1958 the total of such furnaces in the United States was about twelve, with more expected to be added. The total throughout the world is sixty-one, most of them displacing, or successfully competing with, older types of regenerative and recuperative furnaces in areas where fuel costs are high but daily output performance is less than fifty tons.

Up to the present, melting capacities of Unit Melters have covered a range of from less than ten tons to a maximum of forty tons of glass per day. During this year a new, larger Melter for fifty to sixty tons of glass has been designed. Other improvements include the addition of simple heat-recovery systems and improved application of insulation.

Day Tanks

Improvements in tank operation have been made in the casting of crowns for day tanks and wider use of insulation in tank melting. The castable material is said to be quite high in silica and offers encouraging results. No reports have been published on the economics of elec-

tric boosting. Monolithic sidewalls and bottom appear to be a possibility in the near future, and this type of construction has been in use for open-hearth steel melting for some time.

Insulation of the crown is receiving more attention, and attempts to simulate the bottom and sidewalls of the tank are being carried out by the use of an outside wall of fireclay that is lined or paved with fusion-cast refractories.

Electric Boosting

In the United States there are about 30 plants utilizing electric boosting as an aid or "boost" to their melting practice. This procedure, which utilizes electrical energy as a supplement to other fuels, is gaining in popularity.

The electrical energy is usually supplied by means of submerged molybdenum electrodes. The advantages are said to be:

1. More tons per day of glass can be melted.
2. Glass of better quality can be produced.
3. Better refractory life.
4. Better flexibility and control of pull on the furnace.
5. Furnace can operate at a lower firing temperature.
6. Cuts down loss of volatile constituents.
7. Eases firing problems, such as clogging of checkers.
8. Makes batch charging easier with less clogging.
9. The process provides stimulation and control of convection currents.

Automatic Inspection for Containers

A new device has been developed which automatically inspects baby food jars for vertical and radial checks in the finishes. This equipment also has application in any glass ware similar to baby food jars, such as wide mouth food jars or packers tumblers. The equipment is designed to operate at about 70 jars per minute, maximum rate.

The apparatus employs a light beam and photo cell combination. When a check enters the photo cell, a mechanism is actuated to discard the jar. The sensitivity is adjusted so that stray light or false reflections can be discounted according to demands of the inspection. After automatic inspection, the jars may pass visual inspection stations, and finally be automatically cased.

One hundred per cent visual inspection of the ware before it is packed is followed by nearly all manufacturers. The use of equipment for marshaling ware into one or more single files has increased as improved results have been reported from single-line inspection.

Ultimately, it would appear, a large proportion of glass containers will be tested, inspected, and packed by automatic means. There are at present some very close approaches to this goal in specialized production.

Automatic Testing

The introduction of a thermal shock tester has given the industry the first practical device for automatic testing of all ware produced. Designed for installation in the cooling zone of a lehr, the thermal shock tester consists of a circulating and equalizing system, a cold blast system, and a differential temperature control system. Ware leaving the annealing zone is conveyed across a blast of cold air emerging from a slot beneath the lehr belt.

The temperature differential, or degree of thermal shock, is held constant by an automatic temperature control system and is set so that ware of normal quality and strength will stand up under the heat shock without breaking. Defective ware will be visibly cracked and thus easily eliminated. The device is particularly suited to the testing of ware for such defects as bad baffle marks, checks in the base or lower side walls, and general weakness associated with cordy glass. It is ideally suited to the testing of all types of containers and hollow-ware, including pressure ware.

Commercial operation has shown that the shock tester not only eliminates defective ware, but also provides information that can lead to a reduction in the number of rejects and an increased percentage of packed ware. Breakage produced by the tester frequently occurs in a definite pattern on the lehr belt, pointing to 1 and 2 molds which can easily be identified. As a result, corrective measures can be taken more quickly and more effectively than would otherwise be possible.

When combined with certain other types of automatic inspection equipment and automatic bottle packers already being used by several plants, the thermal shock tester provides customers with pre-tested ware of improved quality. Used in conjunction with automatic packers, automatic inspection can reduce manufacturing costs by minimizing packing and inspection labor which now accounts for 30 per cent of the total number of production workers in the average glass container plant.

Improved Techniques for the Container Industry

There is an increasing demand for faster production and for forming machines of greater capacity. More 6-Section I. S. machines are now being used and double-gobbing is more common as a result of angular shearing which permits greater freedom of plant layout.

It used to be necessary to position the I. S. machine at right angles to the feeder axis, but by using angular shears, greater flexibility of the machine installation with respect to the feeder is now possible.

In order to take care of this increased production, larger lehrs, up to 6 feet in width, are becoming common along with gang stackers to handle the higher productivity. The gang stacker which lifts a whole row of bottles from a collecting belt and deposits it, without glass-to-glass contact in the lehr, is solving most lehr-loading problems.

There appears to be a definite trend toward more colored glasses, particularly emerald green and light green. In view of the continued shortage and high cost of selenium, it may be that more and more colored glass will be produced in the future. It is also possible that some new color, such as light amber, a yellow, or a new green that possesses desirable transparency, might be acceptable for packaging many types of food products not now packed in glass.

One major producer in the container field during the past year has developed a forming machine that distributes the greatest weight of glass to the areas of the jar where the most strength is needed. The result has been a container that is 20 per cent lighter, yet just as strong. Furthermore, the machine is capable of producing the product twice as fast with important savings

in labor and raw materials. This development has been accomplished only after more than 12 years of intensive research in engineering and development at a cost of many millions of dollars.

Perhaps the most interesting development of the past year was centered in the carbonated beverage industry. The novelty of the metal can container had hardly subsided, when attention was drawn to the glass container by the "Battle of the Big Bottles," launched by the leaders in the industry.

Prior to 1956, certain areas, such as the Southeast and Texas, had known virtually nothing but the one-drink sizes (six or seven fluid ounces) while other regions—New England and California (particularly Southern California) were known as good "quart" markets.

Then certain industry leaders began to open markets throughout the United States to "family," "king size," or "jumbo" bottles. Ten-, 12-, and 16-ounce bottles, as well as "quarts," were soon being promoted in territories which had never known them before.

Relatively new products in glass or new styles of packs which had very encouraging market tests include fresh citrus fruit sections which are not processed, but are handled under refrigeration. Florida growers are establishing large markets for this product in the Northeast. In California frozen orange concentrate has been successfully market-tested in tumblers decorated with ceramic figures.

Cheese spreads, jams, jellies, peanut butter, and many other products are using these tumblers.

As long as new motifs of decoration are introduced from time to time, there is almost an unlimited demand for these tumblers which can be reused as tableware.

An interesting variation of this theme is a package in the form of a decorated old-fashioned glass.

In the retail store, glass is occuping a more important position than ever before, since the glass package has become its own show window which attracts and sells. Personal selling has been retreating in the face of self-service, not only in the food and beverage fields but also in cosmetics and drugs.

A supermarket study entitled "They Buy By Eye," made by Marathon Corporation, reveals that 78 per cent of the shoppers look first for the picture (or the product itself, if in glass) rather than the lettered name of the product.

Twin Grinding Plate Glass

On September 22, 1953, the double grinding of plate glass was begun at the Rossford plant of the Libbey-Owens-Ford Glass Company, Toledo, Ohio. Rights to the process were obtained through a licensing agreement with Pilkington Brothers Ltd. England. The process is a distinct departure from the usual American methods of plate glass manufacture.

The glass ribbon leaves the furnace and annealing oven as before but, instead of being cut, continues unbroken directly into the twin-grinding machine, which has a series of 22 grinding heads, each weighing 50 tons, rotating above and below the ribbon of glass.

This machine demands facilities for handling and grading 200 tons of grinding sand per hour. The big iron "runners" grinding both sides of the glass simultaneously are more than 100 inches in diameter, the width of the glass sheet moving between them.

Each of the twin-grinding heads can be moved out of line for maintenance and repair work. From the formation of the glass at the end of the tank, to the cut-off after the glass passes through the twin-grinders, is a distance of more than 900 feet. A large machine shop, several overhead cranes, and 2 miles of railroad track are required as auxiliary equipment.

Glass made by this process has a greater degree of flatness and parallelism than is possible by any previously developed method. The grinding heads are precision controlled to reduce both sides of the glass to flat and parallel surfaces. So improved is the new plate glass that it will meet far more rigid specifications for various types of precision than any plate glass made by conventional processes. It can, therefore, be readily adapted for most exacting military requirements where freedom from distortion is essential, such as aircraft glazing and other defense uses. This process should provide a volume source of superior precision glass to meet the demands of mirror manufacturers, architects, and designers.

Glass Molds for Metal Precision Casting

A fast economical method for the precision casting of metals through the use of glass molds has been developed. Designed especially for work with high-temperature alloys, the process assures an excellent surface finish along with the close dimensional control required in precision casting. Because the molds can be used at extremely high temperatures, it is possible to make designs of fine detail and maintain close regulation of metallurgical structure.

In the test production of such items as jet engine bucket and vanes, 90 per cent of the finished castings have met precision standards on surface finish. The process eliminates the precoat step in investment casting and the undesirable cracking and spalling which necessitates rejecting a high percentage of the castings.

The mold powder is essentially a 96 per cent pure silica glass which is mixed with water to produce a casting slip. The slip is poured into a porous plaster mold and allowed to stand from 5 to 10 minutes until enough water has been absorbed to build up a shell of glass solids to the desired thickness.

Excess liquid slip is drained off for re-use, and the glass shell is dried for 15 minutes at 140° F. After removal from the plaster form, the shell is oven-dried at 200° F., and then fired for half an hour between 1740° and 1920° F., depending on the strength desired. The cast mold is then ready for immediate casting or for storage.

The process is suitable for any conventional casting method. This suitability, plus the low tool-up costs and extremely high selection of good castings, means a more profitable operation for the foundries which adopt it. Castings produced by the process have blemish-free surfaces of better than 40 micro-inch finish, requiring little, or no further, conditioning. The mold material has high chemical stability and does not react with the metal or its oxides to cause surface imperfections. Accurate control of grain size is possible, even at metal pouring temperatures as high as 3200° F.

AND NEW PRODUCTS

Optical and Ophthalmic Glass

Optical and ophthalmic glasses of the highest quality are now being melted and homogenized in special furnaces which operate on a continuous basis. These furnaces are of modern design and are controlled by automatic instruments throughout. Special precautions are observed in order to avoid glass contamination of any nature.

An automatic method of forming the molten glass and the rough blanks, approximately the size and shape of the finished product, has been developed. This procedure reduces the final grinding and polishing operations to a minimum.

By this method the molten glass is conducted directly to the forming units, thus eliminating reheating and intermediate processing of any nature. Ware so produced is characterized by clear, transparent surfaces, and blank dimensions of close tolerance. This manufacturing process is suitable for all optical and ophthalmic glasses except fluorcrowns and heavy flints of indices of refraction greater than 1.75.

Methods have been perfected for the manufacture of ware in the form of automatically pressed lens blanks which vary from ½ to 3 inches in diameter and weights of 4 grams to 20 lbs. This ware is used for remolding purposes and may be circular, rectangular, or triangular rods, as well as conventional slabs in a great variety of forms. These improved processes have made the United States independent of foreign sources, and vast new possibilities for production improvement give promise of new tools for scientific research.

Technical Glass

Extremely thin-walled ceramics formed into lightweight honeycomb structures capable of operating at high temperatures have been introduced by Corning Glass works.

Made by the new Cercor process, these materials can withstand temperatures up to 1000° C. (1800° F.) with virtually no thermal expansion and can operate continuously at 700° C. (1290° F.). At these temperatures they are resistant to oxidation and corrosion. A unique characteristic is their low coefficient of thermal expansion: 1×10^{-7} per degree C (from 0 to 300° C.). They can withstand extreme thermal shock.

The special properties indicate that the future of these products lies in gaseous heat exchangers, catalyst supports, and structural materials at elevated temperatures according to Corning.

Pyroceram is used as one of the base materials. Disks 20 inches in diameter and 3¾ inches thick have been made. A protective rim for the disk is formed by a tough coating of special material with matching expansion and equally high resistance to temperatures.

The new structures can also be used as air preheaters and aftercoolers, as burner plates or covers, column packing material, or as architectural materials where lightness, thermal shock resistance and high temperature strength are requisites.

Available Cercor pieces have a compressive strength, parallel to the channels, of 2000 psi. Surface area of the 20-hole-per-inch corrugated structures is 1500 square feet per cubic foot of material. Of the total face area, 75 to 80 per cent is open space. Hole sizes are approximately 0.095 inch long and 0.045 inch high. It is believed that the cellular holes can be formed into a variety of shapes with a wide range of dimensions. The material has a density of about 30 pounds per cubic foot and a specific heat (room temperature) of 0.20. The average wall thickness of the corrugated structure is 0.005 inch.

Important Use for Glass Tubing

Borosilicate glass tubing turns up in unusual and vital places. For example, the Sylvania Strobeacon recently celebrated its 10th anniversary at Newark Airport, where 23 of these lamps were installed along a single 2,400-foot lane in the runway approach path. Each tiny lamp (about 2¼ inches high) gives an ultra-brilliant beam of over 200,000,000 peak lumens from its high intensity flash tube made of glass tubing. Since that time it is estimated that approximately 40,000 flights have been guided to safe landings at Newark by the system.

The light produced by one of these units is approximately five times greater than that of the most powerful lighthouse in use today; the units flash in sequence toward the runway giving the effect of an animated arrow. They can effectively pierce fog, mist, and smoke. Several of the larger airports in the country use this approach lighting system, although it is limited by the amount of pre-runway space available to an airport.

Heat Exchanger

A borosilicate-glass shell and tube heat exchanger, virtually impervious to corrosion, has been developed especially for processing industries, where chemical resistance and product purity are primary considerations.

Field tested for a year, the 50-square-foot capacity heat exchanger has proven highly efficient, versatile and economical to install, operate and maintain. Extreme operational flexibility is assured because working parts resist attack by all acids except hydrofluoric.

The light-walled tubes have a conductivity coefficient, h, of 260 BTU/hr/ft²/ Deg F and overall values, U, have been meaured up to 195 BTU/hr/ft²/Deg F in water-to-water tests. The straight-line flow and smoothness of the glass assures extremely low friction loss. Operating temperatures up to 375° F. are possible on the shell side and 200° F., on the tube side, while operating pressures can be as high as 20 psi.

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TEN Years of Progress in the Glass Industry

RAW MATERIALS

● THE GLASS INDUSTRY is constantly alert to the use of purer, as well as new and versatile, raw materials. Developments in this field have been especially significant in the application of newer alkaline materials that have included lithium, rubidium, and cesium chemicals as well as a number of rare earth products. Other significant developments have been in the improved sources of alumina, better slags, and a greater number of phosphate raw materials.

Lithium minerals, such as lepidolite, spodumene, and petalite, are assuming greater importance in specialized glass batches. It is estimated that 60-70 per cent of all glass TV picture tubes now contain lithium. These minerals, especially petalite, are being used in glass tubing, head lamps, top-of-stove ware, and various borosilicate glasses. Optical and ophthalmic glasses are also utilizing lithium in various amounts. The result has been short supply of these raw materials. New sources of supply in the United States are being developed, and should meet increasing demands for these materials.

Various slags are being applied and used as a partial flux and an aid to melting. These applications are for the most part used in cheaper ware where color is not a vital factor.

Lithium Raw Materials

Development of the hydrogen bomb and intense industrial promotion have raised the world's lightest metal, lithium, from obscurity to a stellar role in half a dozen civilian and defense industries in the last 5 years. The 4 major lithium producers in the United States which account for the bulk of the world production are the Lithium Corporation of America; American Lithium Chemicals, Inc., jointly owned by American Potash and Chemical Corporation and Bikita Minerals (Pvt) Limited; Foote Mineral Company; and Maywood Chemical Works.

Because spodumene production in this country was withdrawn from the glass market early in 1954, this industry is at present dependent largely on import tonnages. It has been estimated that of the total imports of lithium minerals in 1954, approximately 17,000 net tons of petalite, 12,000 net tons of lepidolite, and 1,000 net tons of spodumene have been used.

The vast majority of these tonnages is consumed in glass, with the principal uses continuing to be television glass and various borosilicate glasses. It is estimated that approximately 70 per cent of the glass consumption of lithium ore is specifically in electronics and television glass, while 20 per cent has been devoted to borosilicate glass, and slightly less than 10 per cent for miscellaneous glass uses.

The total dollar volume of lithium ores purchased by the glass industry during 1954 was about $1¼ million.

The supply position continues to be exceedingly good on imported lithium minerals. A beneficiating system has been provided which makes available much more uniform material having very low impurities which are blended to exacting lithium oxide contents.

Actual domestic production of spodumene has been been carefully shrouded in security secrecy, but it far exceeds our present import tonnages. Although much of the present expansion in the lithium industry is backed by Government support, it is expected that civilian sales will represent 80 to 90 per cent of the total business for the next year or so.

Lithium Supply Grows

Broadening use of atomic energy and intense industrial promotion continue to raise the requirements and demands of lithium raw materials. Commercial requirements of lithium chemicals for 1955 were estimated at 9 million pounds with lubricating grease and ceramics each accounting for about 3.5 million pounds. It would appear that under the stimulus of atomic energy and Government support the supply is greatly improving. Substantial improvements in efficiencies in new plants have been made with improved flotation mills meaning higher lithium concentrates.

At present Foote Mineral Company produces about 40 per cent of the industry's capacity. Its efforts are largely concentrated at the Sunbright plant.

The Bessemer City, North Carolina, plant of the Lithium Corporation of America charges spodumene ore of 1.4 per cent lithia direct to process without intermediate concentration and enjoys very good over-all efficiency and yield.

Limited to by-product output of about 1.5 million

pounds at Searles Lake, California, the American Lithium Chemicals, Inc., jointly owned by American Potash & Chemical Corporation and Bikita Minerals (Pvt) Ltd., has constructed a $6.6 million lithium chemicals plant at San Antonio, Texas, to process lepidolite ore imported from Rhodesia.

An expansion of lithium consumption in new areas of the glass industry can be visualized also in such outlets as lithium hypochlorite dry bleach, lithium fluoride, or carbonate, as an additive for aluminum production in the bauxite-cryolite bath, and as an intermediate chemical for the manufacture of boron hydrides.

It is estimated that in 1956 imports of lepidolite and petalite for glass manufacture totaled approximately 18,000 tons, which means that for the first time in 3 years imports were approximately in balance with consumption. The tonnage spreads to approximately ⅔ petalite and ⅓ lepidolite.

These figures reflect only ore destined for glass consumption. There were additional, lesser tonnages brought in for other ceramic use, and for lepidolite, in particular, tremendous tonnages for chemical use.

Explorations of lithium ore reserves continue to report mounting tonnages. This reserve has inspired various established and projected research projects of a relatively basic nature. One project has been directed toward a study of the properties relating to glass-forming areas in various basic systems. These projects are aimed at providing the industry with sufficient basic knowledge to enable glass technologists to apply lithium oxide in particular and lithium ores in general in the compounding of approved glasses.

Lithium minerals are now established on a high-quality basis involving a high degree of control which requires procedures never before necessary in any of the more common glass batch ingredients. While the growth of lithium mineral use in glass has been the result of mounting requirements of a few particular glasses, the expanding knowledge of reserves in general gives rise to researchers' looking forward to a much broader use. Furthermore, prices over the last two years have decreased, and it is quite likely that they will continue to do so in an orderly fashion in the near future.

Little or no spodumene has been imported for glass manufacture. Tremendous reserves have been developed both in Canada and the United States; however, all the tonnage thus far has been directed into chemical manufacture of one type or another. Known reserves could conceivably supply a considerable demand for glass manufacture; however, very little study of a glass grade spodumene product has been made to date. Such projects are of extreme interest and will no doubt be undertaken in the near future.

The glass industry is constantly alert to the prospect of new materials that may enhance or provide new and unusual properties for products. The fluxing power of alkali carbonates such as sodium carbonate and potassium carbonate, has been known for many years.

The availability of these fundamental materials in high purity provides the glass and ceramic industry with the possibility of creating new glasses with possibly startling properties.

In general, rubidium compounds resemble the compounds of the other alkali metals. However, significant differences are evident because of variation in ionic dimensions, different heats of hydration, and the ease with which the outer electron is lost.

A similar series of cesium compounds is also available for commercial evaluation. Although cesium has properties similar to the other alkali metals, it is the most reactive member of the group. Because of its greater atomic weight and radius, pronounced differences exist as evidenced by comparing the solubilities of various salts in water and comparing the ionization potentials of the gaseous atoms.

The action of these higher atomic weight alkali metals in glasses is not specifically known. It is quite probable, however, that definite effects will be noticed in such properties as rate of melting, softening point, viscosity workability, annealing, density, and refractivity. It is also possible that durability may be influenced. Colors and electrical properties are also known to be profoundly influenced by size and mobility of the alkali cation. One would expect rubidium to react similarly to potassium, only more so, because of its ionic radius and mobility. Cesium, on the other hand, is very reactive and may show other properties and characteristics. The possible applications of these interesting new materials are extremely great in effecting crystal growth, crystal formation, or in modifying glass properties.

Lithium minerals are being improved and becoming more readily available. The current year's consumption of lithium minerals by the ceramic and glass industries has changed somewhat over the past several years and further substantial changes are in prospect. The total consumption this year is estimated to be the equivalent of, if not slightly higher than, last year's 18,000 tons.

Lepidolite use has increased over petalite, with the consumption being approximately 9,000 tons each. Approximately two-thirds or 6,000 tons of lepidolite was used in television glass and the balance in borosilicate glass. A negligible amount was used in other glasses and in ceramics. The "other glasses" actually include several hundred tons in porcelain enamels. Of the 9,000 tons of petalite consumed, approximately 60 per cent was used in television glass, none in borosilicate, and the balance in whiteware ceramics, and porcelain enamel frits.

Basic glass research involving lithium oxide was broadened during 1957. The lithium chemical producing industry, sponsor of the American Lithium Institute, has established a basic study of lithium in glass.

There have recently been broader studies by both Canadian as well as domestic manufacturers to develop a glass grade spodumene. The total output of both countries to date remains a so-called chemical grade, while the development of a glass grade has advanced to the large pilot plant stage at the present time. The prospect for glass grade spodumene is most encouraging.

This prospect has considerable significance in view of the large reserves of spodumene on this continent, providing the glass industry the security of a domestic over an imported foreign supply of lithium minerals as well as the prospect of lower cost lithia values.

It is not expected that spodumene *per se* will supplant

(*Continued on page* 661)

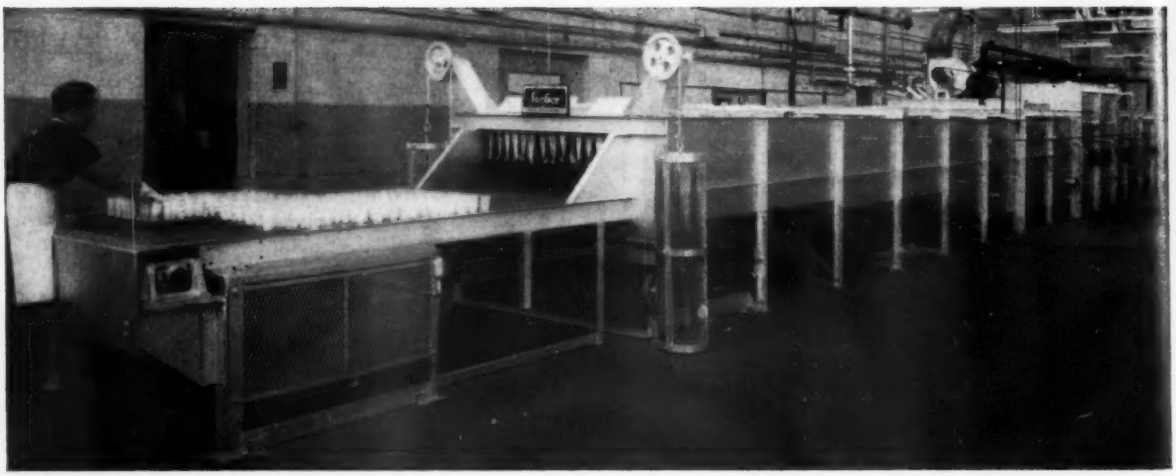
a "useful life" can cost you money

Depreciation policies based on the useful physical life of equipment have lulled many companies into dangerous complacency. By ignoring inflation and technological obsolescence, they pay dividends and taxes on profits which don't really exist.

Inevitably, they discover that their depreciation reserves are inadequate to replace worn out or obsolete equipment.

However, aggressive managements have found two alternatives to that dilemma. First, they prove to the Government that their depreciation rates should be based on the economic—not the physical—life of their equipment.

Second, they purchase equipment which will recoup their investment within its economic lifetime. This is the factor which prompts many companies to specify Surface Combustion lehrs, kilns, and ovens.



This radiant tube decorating lehr is recouping its owner's investment.

Surface Combustion Corporation

2378 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ont.

wherever heat is used in industry

Surface

NEWS in The Glass Industry

Thatcher Begins Tampa Plant Construction

Thatcher Glass Manufacturing Company has begun construction of its $3,500,000 glass container manufacturing plant in the Tampa Industrial Park, Tampa, Fla.

The 180,000-square-foot structure will be completed in the spring of 1960 and will have an annual capacity of 100,000,000 glass bottles. The new operation will be Thatcher's eighth plant in the United States.

Earlier this year the company acquired The Celon Company, Muscatine, Iowa, and Plastic Tube and Bottle, Inc., Nashua, N. H.

Twentieth Conference on Glass Problems

The Twentieth Conference on Glass Problems will be held on Thursday and Friday, December 10-11, at the University of Illinois, Urbana, Ill., in the Department of Ceramic Engineering.

The first session on Thursday will concern problems in the glass preparation and forming phases of manufacture:

Currents in Glass Furnaces. W. R. Schlehr, Ford Motor Co., Dearborn, Mich.

Some Aspects of Glass Flow in Tanks. Alfred R. Cooper, Massachusetts Institute of Technology, Cambridge, Mass.

Use of Bubblers in the Glass Furnace. Ralph T. Brannan, Owens-Corning Fiberglas Corp., Newark, O.

Radiant Heat Transfer in Glass Tanks. Robert Gardon, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

Basic Considerations for the Selection of Refractories for the Glass Industry. Harold W. Baque, Corhart Refractories Co., Louisville, Ky.

Some Aspects of Mold Dopes and Their Use. Owens-Illinois Glass Co., Toledo, O.

Use of Silicones in Glass Manufacture. John A. Stapp, Union Carbide Corp., Tonawanda, N. Y.

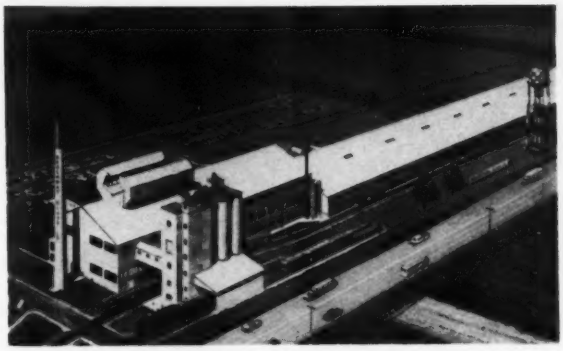
The half-day session on Friday will deal with some fundamental properties of glass, both in manufacture and use:

Color and Transmittance of Green Container Glass. W. R. Lester, Hartford Empire Division of Emhart Corp., Hartford, Conn.

Problems Relating to the Chemical Durability of Glass. J. F. Greene, Kimble Glass Co., Vineland, N. J.

Strength Properties of Glass: Requirements for Superior Performance. Richard E. Mould, Preston Laboratories, Inc., Butler, Pa.

For further information write to Dr. F. V. Tooley, professor of glass technology, University of Illinois, 208 Ceramics Bldg., Urbana, Illinois.



Architect's drawing of Brockway Glass Co. multi-million-dollar glass container manufacturing plant to be built in Minneapolis-St. Paul area.

Brockway to Build Plant in Minnesota

Brockway Glass Company will break ground for its multi-million-dollar glass container manufacturing plant in the Minneapolis-St. Paul area early next Spring. Production of flint and amber glass containers for the company's food, beverages, Rx, beer, liquor, pharmaceutical and proprietary divisions will start in the Fall of the same year.

The modern steel and concrete building will house both manufacturing and warehousing areas; a 50-acre site has been set aside for future expansion.

Brockway has operations in Brockway and Crenshaw, Pa.; Freehold, N. J.; Lapel, Ind.; and Muskogee, Okla. in addition to its wholly-owned subsidiary companies, Demuth Glass Works, in Parkersburg, W. Va., and Tygart Valley Glass Company in Washington, Pa.

Hatchley Retires from Borax & Chemicals

William J. Hatchley has retired as managing director of Borax & Chemicals, Ltd., and George H. Poole & Company, British subsidiaries of American Potash & Chemical Corporation. He has been with Borax & Chemicals since its formation in 1939.

Erratum

On page 528, October issue, it is erroneously stated that Dr. Norbert J. Kreidl, director of chemical research, Bausch & Lomb Optical Co., is associated with another company. Dr. Kreidl served as chairman of the Symposium of Radiation Effects at the American Ceramic Society's Fall meeting at Galen Hall last month.

We regret this obvious error and hope this announcement will serve to correct any misunderstanding that may have resulted.

Dr. Donald S. Arnold

Dr. Robert C. Wilson

Arnold Named at American Potash & Chemical

Dr. Donald S. Arnold has been named manager of Research at American Potash & Chemical Corporation's main plant at Trona, Calif., succeeding Dr. Donald E. Garrett.

American Nepheline Appoints Wilson

Dr. Robert C. Wilson has been appointed technical service representative for the ceramic industry by American Nepheline Limited, Toronto, Ontario. He will act as a liaison for production, research and sales.

H. K. Porter Opens Pascagoula Works

The Refractories Division of the H. K. Porter Company, Inc. formally opened its $12 million refractories plant in Pascagoula, Miss., on September 18.

The Pascagoula Works furnishes the glass industry with refractory brick for glass tank checkers and upper structures. The facilities contain a sea-water chemical plant which produces 125 tons per day of high-purity, dead-burned periclase, and a basic brick plant which converts the periclase and chrome ore into basic refractories.

Magnesia produced at the sea-water plant is manufactured into chrome-magnesite, magnesite-chrome and steel-encased bodies. These are used extensively in glass manufacturing.

Allan Austin, president, Austin Co., presents C. L. Holbert, president, H. K. Porter Co., with key symbolizing completion of construction and transfer of Pascagoula, Miss., refractory works to Porter management.

1959 Meyer and Forrest Awards

The Frank Forrest and the S. B. Meyer, Jr. annual Awards of the American Ceramic Society (Glass Division) were presented at Galen Hall, Wernersville, Pa., on Thursday evening, October 15. Both sponsored by Preston Laboratories, these awards are equal in requirement and merit. Their purpose is to encourage the publication of papers in the field of glass technology.

The Meyer Award. Presented to E. M. Levin and Dr. Stanley Block for their paper, "Structural Interpretations of Immiscibility in Oxide Systems: Part I, Analysis and Calculation of Immiscibility; Part II, Coordination Principles Applied to Immiscibility." These articles were published in the *Journal of the American Ceramic Society* in 1957.

Mr. Levin has been associated with the National Bureau of Standards as a physical chemist since 1937 and has directed his research toward studies of lime and gypsum as well as high-temperature phase equilibria. He received his B.A. degree from the University of California in 1935 and his M.A. degree from the same University in 1938, continuing his graduate work at George Washington University in 1944 and 1945. Mr. Levin is a Fellow of the American Ceramic Society.

Dr. Stanley Block, a member of the Micro-Structure section of the Mineral products division, National Bureau of Standards, has devoted most of his work to the crystal structure of inorganic compounds. He studied at Johns Hopkins University as an undergraduate where he received a Ph.D. in Physical Chemistry in 1955.

The Frank Forrest Award. Presented to Dr. Clarence L. Babcock and D. A. McGraw for their paper, "Application of Glass Properties Data to Forming Operations," which was published in THE GLASS INDUSTRY in 1957.

Dr. Babcock, chief glass technologist at the Owens-Illinois Glass Co. since 1945, has been concerned mostly with the measurement of glass properties and their engineering applications.

He received a B.A. degree from Ball State Teachers College in 1928 and a M.S. degree (1931) and a Ph.D. degree in physics (1936) from Purdue University. At Purdue University he held a Research Fellowship sponsored by Corning Glass.

Dr. Babcock was an instructor in high school in Indiana from 1923 to 1930 and an instructor in Physics at Purdue University from 1930 to 1935. He is a Fellow of the American Ceramic Society.

Mr. McGraw, a research physicist since 1945 in the general research department of Owens-Illinois Glass Co., has devoted his research to the study of heat transfer in glass. He received a B.A. degree from Concord College in 1937 and a M.S. degree in Physics from West Virginia University in 1939. He studied at the University of North Carolina in 1939 and 1940. From 1941 to 1945 he engaged in research on ballistics at Hercules Powder Co.

Mr. McGraw was previously honored in 1952 when he received the Forrest Award for his research on the modulus of elasticity of glass.

84-inch Telescope Mirror Blank

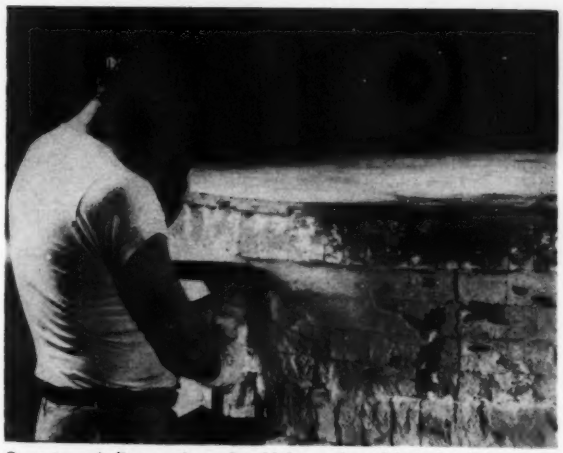
Corning Glass Works has completed an 84-inch telescope mirror blank of borosilicate glass for the new Kitt Peak National Observatory under construction 40 miles southwest of Tucson, Ariz.

In producing the blank, nine chunks of glass, one weighing 2,976 pounds, were placed on the mold and melted by temperatures reaching approximately 2300° F. To reduce weight and still retain the necessary strength and rigidity, a honeycomb pattern was formed on the back face of the blank by ceramic cores, bolted and cemented into the floor of the brick mold.

The disk is said to be the biggest piece of glass ever made by the sagging process. This method, state Corning engineers, reduces bubble inclusions and is less complicated and less costly than the ladle method which they used in the production of the 200-inch disk for Hale Observatory atop Palomar Mountain in California and the 120-inch mirror now in use at the Lick Observatory on Mount Hamilton in California.

The 4,000-pound mirror blank was sealed in an annealer for seven months to insure controlled cooling. After its removal it was shipped to Tucson, Ariz., where an optical shop has been set up for grinding and polishing. An estimated 24 months will elapse before this job is finished. Then the mirror will be installed in the telescope and fixed on a star, after which the final precision finishing will be done.

The Kitt Peak Observatory, a facility of the National Science Foundation, is being operated under contract by the Association of Universities for Research in Astronomy, Inc.



Operator grinding portions of mold from edge of 84-inch telescopic mirror blank, which was formed by the sagging process.

Frank Klane, left, and Ray Sweet, Corning Glass Works engineers, inspect ceramic cores in mold of 84-inch telescope mirror blank, which was cast for the Kitt Peak National Observatory, Tucson, Ariz.

Welsch Joins Thatcher Glass

Jack Welsch has joined Thatcher Glass Manufacturing Company, Inc. as vice president, glass container sales, with offices in New York City.

Left to right: Wallace K. Wood, Wallace China Co., Ltd., receiving Pennsylvania Glass Sand Awards Golf Trophy after winning annual golf outing of the Pittsburgh section, American Ceramic Society; Richard W. Richer, chairman, Pittsburgh Section; and Dan G. Sloan, Pennsylvania Glass Sand Corporation, who presented the Trophy.

Dr. Mueller Joins Pemco

Dr. E. E. Mueller, formerly associate professor of ceramic engineering at the University of Washington, School of Mineral Engineering, has joined the Pemco Corporation. He will engage in research on the application of ceramic materials to new markets.

Plunkett, Adv. Mgr., PPG Fiber Glass

James C. Plunkett, advertising manager of Columbia-Southern Chemical Corporation, since 1951 has been appointed advertising manager of Pittsburgh Plate Glass Company's fiber glass division. He has been succeeded in the Columbia-Southern post by Richard C. Oswant, editor of Columbia-Southern *Chemical's* magazine.

Pittsburgh Plate produces fiber glass at Shelbyville, Ind., and Shelby, N. C., and is presently expanding the latter operation into a 24-furnace direct-melt system.

Robert A. Sanders

T. A. Rohlfsen

Oakite Appoints Rohlfsen

T. A. Rohlfsen has been appointed manager of the South Pacific coast division of Oakite Products, Inc., succeeding J. C. Leonard who retires after 35 years of service with the company.

Mr. Rohlfsen will direct the activities of the technical service representatives in Southern California.

Pittsburgh Appoints Snyder

Walter D. Snyder has been appointed general manager of operations for the merchandising division of Pittsburgh Plate Glass Company. He succeeds Harry R. Kluth who has retired after 50 years' service with the company.

Graziano in J-M Fiber Glass Post

Gasper Graziano, formerly in the Johns-Manville general plant engineering department, Manville, N.J., has become resident engineer of the company's expansion program at the fiber glass blanket insulation materials plant in Defiance, Ohio.

The expansion includes two insulation manufacturing machines which will be housed in separate 15,000-square-foot wings. Both units will be in operation early next year.

The newly recognized capacity will be directed toward materials for the industrial and commercial field, and smaller amounts will be used by the automotive and transportation industries.

Knox to Sell 200,000 Shares of Stock

Knox Glass, Inc., has filed a registration statement with the Securities and Exchange Commission covering a proposed public offering of 200,000 shares of the company's common stock.

The net proceeds from the sale, together with funds to be received from a $2-million bank loan and a $6,000,000 long-term loan from an institutional investor, will be applied in part for repayment of all the company's outstanding indebtedness. The balance of the proceeds will be used to provide machinery, equipment, and working capital for a proposed plant to be constructed in the Southeast, and for general corporate purposes.

An investment banking group headed by Smith, Barney & Co. will underwrite the offering.

Sanders Appointed Manager for New Corning Plant

Robert A. Sanders has been appointed manager of Corning Glass Work's Pyroceram cooking utensil manufacturing plant, to be built at Martinsburg, W. Va.

Mr. Sanders has been with the company since 1946 and has served as general foreman of the forming department at the Albion, Mich., operations; production superintendent of "A" factory at the main plant in Corning, N. Y.; and assistant to the manager of manufacturing for the consumer products division.

The new 244,000 sq.-ft. plant will house production equipment for the Corning Ware line of saucepans, skillets and percolators.

American-Saint Gobian Selects Trade Mark

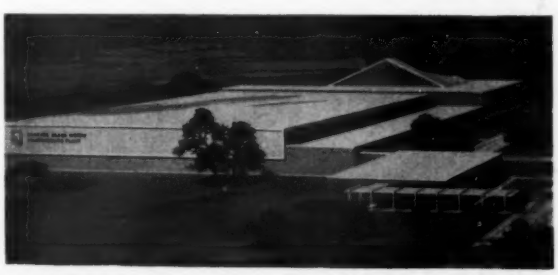
The American-Saint Gobain Corporation has chosen as its trade mark a triangle of three triangular glaziers' points representative of the three types of flat glass the company will be producing by 1962 —plate, sheet and rolled.

The emblem is formed with two equilateral triangles placed upright side by side and the third triangle atop the other two with its base resting on the apex of each, so that the three form a larger equilateral triangle.

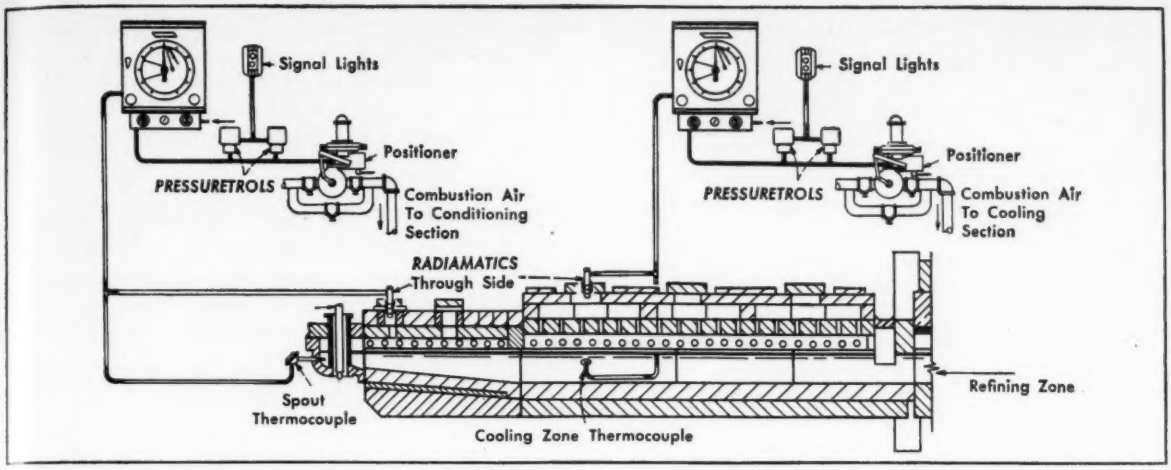
American-Saint Gobain Corporation was formed in May, 1958, by the merger of American Window Glass Company, Pittsburgh, Pa., and the Blue Ridge Glass Corporation, Kingsport, Tenn., a wholly owned subsidiary of Compagnie de Saint-Gobain, Paris, France. American-Saint Gobain is planning a new plate glass plant at Greenland, Tenn., which will have an annual capacity of 40,000,000 square feet of ½-inch plate glass. It will contain twin-polishing machines used in conjunction with twin-grinding lines that permit the continuous grinding and polishing of a ribbon of plate glass simultaneously on both sides.

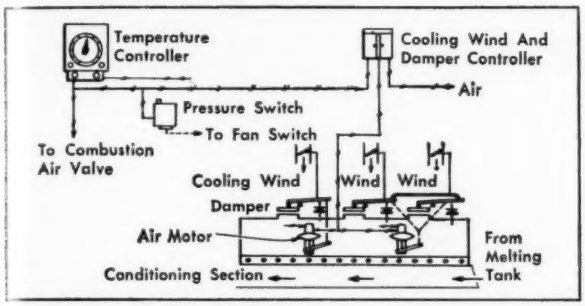
The company is constructing this plant in anticipation of substantial growth in demand and consumption of glass in the next decade by the automobile, construction and home furnishings industries.

Saint-Gobain, has produced plate glass in France since 1665 and is a leading producer of window, rolled and fiber glass, hollow glassware, borosilicate glass and other glass products.

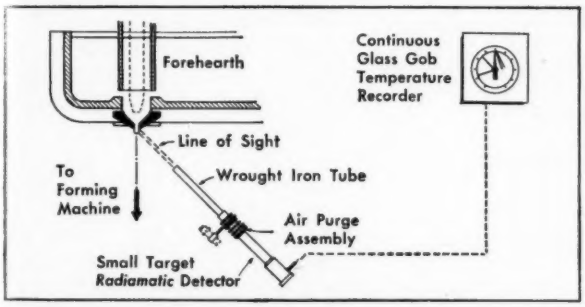


Sketch of Corning Glass Works plant to be constructed at Martinsburg, W. Va., for production of Corning Ware utensils.

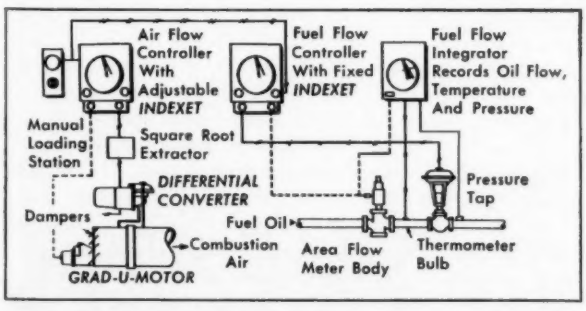




COOLING WIND CONTROL—provides accurate, automatic control of both heat and cooling wind for higher machine speeds and larger gross pack, more uniform forehearth temperature, less fuel consumption.



CONTINUOUS GLASS GOB TEMPERATURE MEASUREMENT—provides continuous record and indication of actual gob temperature.



MELTING UNIT INSTRUMENTATION—keeps glass quality uniform; saves fuel; increases furnace life by precise control of fuel, combustion atmosphere, furnace pressure, and temperature. Engineered automatic reversal helps achieve and maintain peak efficiency.

PNEUMATIC OR ELECTRIC FOREHEARTH CONTROL—assures precise glassware weight, higher machine speeds and larger gross packs. For electric control, Brown *Electr-O-Volt* control unit and electric actuators. For pneumatic control, Brown *Air-O-Line* control unit and pneumatic actuators. Sensing elements are either thermocouples or *Radiamatic* radiation pyrometers as desired.

Complete glass plant instrumentation developed for you by Honeywell...

These four control systems were developed by Honeywell, and are manufacturing better glass products more economically. What they do for others, they can do for you.

Honeywell, first to apply automatic control to the making of glass, has pioneered new techniques of measurement and control. For the future, it has built a unique body of experience and know-how to continue to meet the industry's expanding needs.

Ask your nearby Honeywell field engineer to help you gain the advantages of complete glass plant instrumentation. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL *First in Control*

FIBER GLASS

(*Continued from page* 613)

interliners, concrete curing papers, building papers, and many types of wrapping papers.

Cable Insulation

Glass fiber yarns have been combined with asbestos spinning fiber to make new tapes for cable insulation. These tapes are examples of the effective union of glass fibers and asbestos, for the resultant products retain the best characteristics of each material. They are superior in some respects to the all-asbestos materials they replace and are less costly to use.

The combination of asbestos, glass, and asphalt provides as nearly as possible a rot-resistant combination. It sells for about twice the price of asbestos roving but, nevertheless, produces a more economical cable. The asbestos felting must be saturated, taken to an oven to be dried, and then returned to the cabling machine for additional processing. This tape enables the designer to provide a saturated wall using taping heads and makes it more possible to complete the cable in one operation.

Crude Oil Storage

A new type of corrosion-resistant crude oil storage tank is said to outlast conventional types, reduce vapor losses, and afford lower shipping costs and easier erection. They are made of reinforced plastics, combining glass fiber mat and polyester resin, to standard specification in conventional sizes, ranging from 250 to 3,000 barrel capacities.

The exceptional resistance of the material to corrosion and electrolysis, its insulating value, high strength, and low weight indicate that reinforced plastic tanks offer the oil industry many outstanding economies. In contrast to conventional galvanized steel storage tanks, this material is impervious to damage by hydrogen sulfide gases, salt water, electrolytic action, and other deteriorating influences from crude oil storage.

Military Applications

Over half of the glass-polyester parts now being made are for military application. Radomes were one of the first applications and among the largest pieces still being made. The material is strong enough to withstand the air pressure in aircraft; corrosion by salt water and rain is no problem. Most important, glass-polyester is transparent to electromagnetic radiation, with solid and honeycomb structures being used.

Ducts for the B-47 jet bomber have been molded from preforms, with weight saving being one major advantage over aluminum. Junction boxes and most of the safety equipment are also B-47 applications. Other military applications are crash helmets and bullet proof vests.

Pipe Repair Method

A simple, fast, foolproof method for repairing leaking or broken pipe on shipboard has been devised. Glass fiber tape, cloth, or mat, saturated with an epoxy resin, is placed over the hole and permitted to cure. Application of the patch takes 5 to 10 minutes, with an additional 30 to 45 minutes required for curing. The patch will withstand pressures as high as 2,000 psi, and it is bonded so securely to the pipe that it can never be removed.

It is 100 per cent watertight, and any type of break can be repaired. Only minutes are required, and no special equipment is necessary except for a small kit of resin, glass fiber material, and accessories.

Glass Fiber Ingot Mold Liner

A new and improved method has been developed for casting steel ingots free from surface imperfections and defects. By placing a glass fiber barrier or liner between the ingot wall and the metal stream entering the mold it is possible to prevent splashing.

Fiber glass has proven to be ideal for this purpose, because it prevents the splash from contacting the walls of the mold and decreasing or minimizing the surging effects of the metals. Glass fibers do not leave a large amount of residue, and the glass converts to a small quantity of liquid slag that easily floats out in the metal being poured. Further, the glass fiber barrier is more non-reactive, a poor conductor of heat, easy to install and relatively inexpensive.

Miscellaneous Applications

A number of other applications are included. Lightweight bath tubs for house trailers; loud speaker horns; shower stall bases; liners for ice chests and frozen food containers; and pressure containers for dispensing hot and cold beverages. Another proposed application is table-top and panel material made by molding the material around balsa cores.

Hollywood is building most of its big movie sets of glass fiber products. The high scene in the movie, *Samson and Delilah*, in which Samson tore down the huge pillars of the prison house and tons of stone crashed upon Samson, and 3,000 Philistines, was effectively staged by means of fiber glass. On the screen the casualties were enormous; but actually no one was harmed, mainly because the pillars and blocks were made mostly of glass.

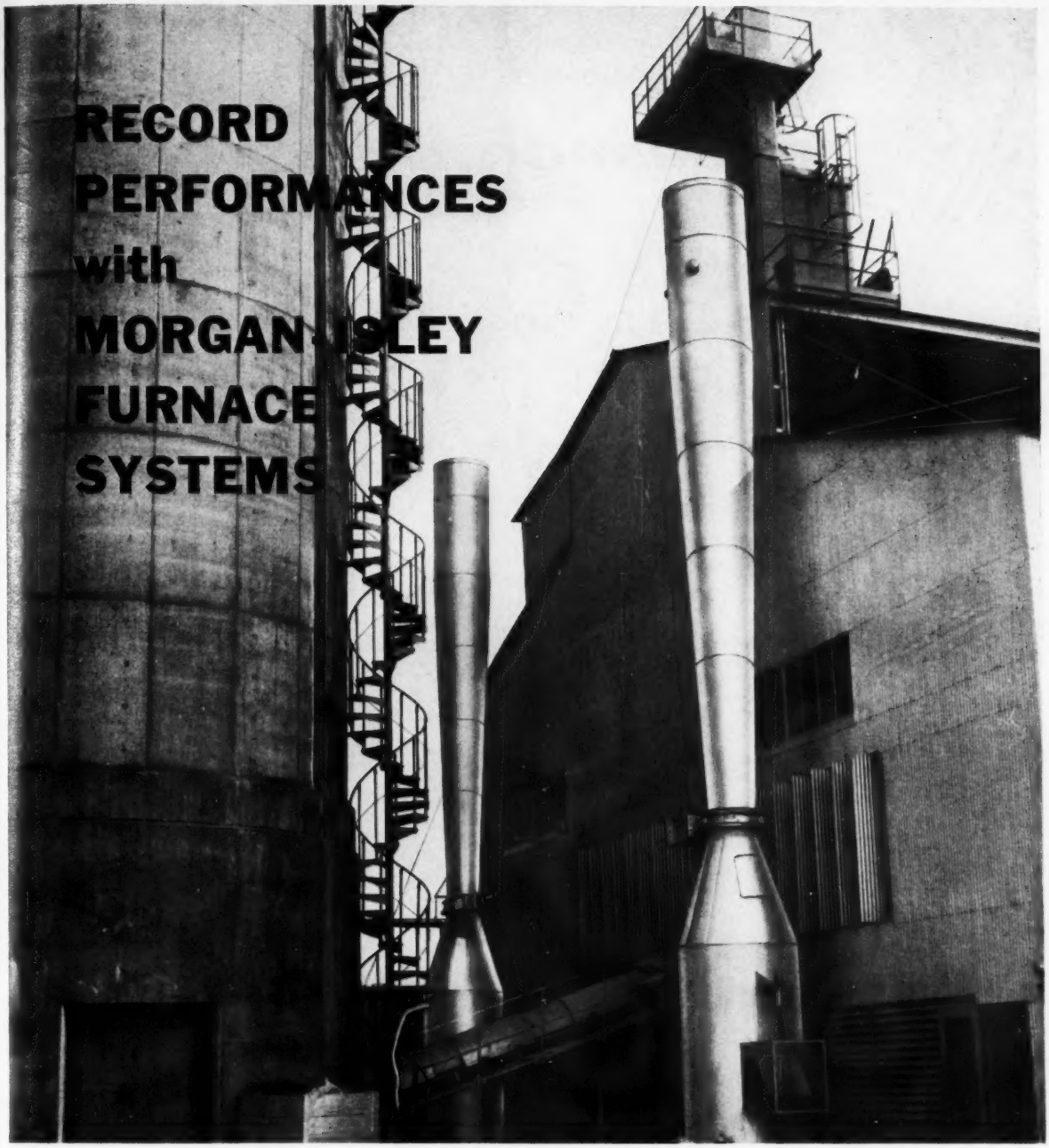
Glass fibers, in plaster of Paris, had been sprayed on molds, forming "stone" blocks that were mere shells, but of great strength but light in weight. The material actually was only one-eighth of an inch thick.

Boat Hulls

Boat hulls made of fiber glass are said to be lighter, faster, and more durable than wooden boats of the same price. Ford station wagons are rolling off assembly lines with glass fiber trim replacing wood, at half the price of the previously used hard maple. Ford is also using a glass fiber plastic top for its Thunderbird sports car.

The glass fiber boat stamping is drawing much attention because the manufacturing process is closely related to mass production of auto fenders and body panels. For many years, automakers have eyed plastic as a possible light-weight replacement for sheet metal bodies, but they have never solved processing difficulties. It is hoped that the boat pressing experience may provide some of the answers.

Presses ranging from 100 to 700 tons have been used, and any one of them is capable of handling fenders or auto body panels.



Illustrated above is a MORGAN-ISLEY SYSTEM with secondary regenerators at United Can and Glass Company, Hayward, California. This furnace melted a record-breaking 254,036.6 tons in 1773 operating days with a melting area of 676 square feet and an average fuel consumption of 5979 cubic feet (natural gas) per ton. The Morgan-Isley system can help you approach record-breaking performances.

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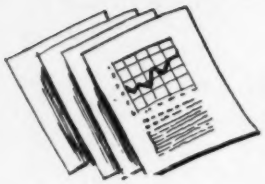
MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS

CCC57



RESEARCH DIGEST

Silicones for Surface Protection

● In the June, 1959, News and Reviews section of the *Journal of the Society of Glass Technology*, T. J. Mahoney presents a brief discussion on the use of silicones for surface protection of glass containers.

An anti-seize agent for glass containers should possess several properties.

1. The material should be an excellent lubricant for glass.
2. Treated glass surfaces should slide easily on each other rather than abrade.
3. The material should be easy to use.
4. Application should be possible over a wide range of temperatures to meet various operating conditions.
5. The material should be inexpensive and not interfere with labelling.
6. Analyses of the quantity of the material in the containers should be easy to facilitate permission for usage on food containers.

TABLE I

STATIC COEFFICIENTS OF FRICTION FOR SODA-LIME GLASS AGAINST SODA-LIME GLASS; LUBRICANT APPLIED AS AN UNDILUTED SMEAR

LUBRICANT	Fs at the following temp. (°C) 200	150	95	30
None	0.9	0.85	0.9	0.85
L-45 Dimethylsilicone	0.005-0.1	0.1	0.1	0.15
XL-520 Organosilicone Fluid	0.005-0.2	0.05	0.05	0.1
L-522 Organosilicone Fluid	0.7	0.05	0.05	0.1

Lubricity is one of the most important requirements of an anti-seize agent. One method that has been used to determine this property is the slide-angle test, in which the angle required for a bottle to slide from the top of a pyramid of three bottles is measured; the smaller the angle, the more efficient the lubricant. The results of this test depend to some extent on bottle geometry and on the efficiency of application of the anti-seize agent.

To obtain more fundamental information on the lubricity of anti-seize agents, a method was devised to measure static coefficients of friction of glass on glass. This work has been described in detail by West & Mahoney. The coefficient of friction between a slider and a flat specimen or plate was measured. The force required to initiate sliding was determined by adding water to a container connected to the slider via a light cord which passed over a pulley. The frictional force F divided by the load W gives the static coefficient of friction, $F_s = F/W$.

The lubricants were applied to glass specimens as an undiluted smear. Several anti-seize materials were also screened by applying dilute aqueous solutions to soft glass. The results of these measurements are presented in Tables I and II.

The lubricity tests suggest that the material containing silanic hydrogen and Union Carbide XL-520 might be the best anti-seize agents. For a material to be easy to use, it must be dilutable with water. The material containing silanic hydrogen must be emulsified to achieve this end; such emulsions evolve hydrogen gas on standing and tend to coagulate. On the other hand, XL-520 is not a reactive material but rather a silicone fluid with extremely low surface tension that orients itself on the container surface, it cannot be overcured and embrittled by too high an application temperature. Successful applications have been made at bottle temperatures from 70° F. to 400° F.

Bottles sprayed with XL-520 were examined by several adhesive manufacturers and only one type of label adhesive was found not to be suitable for use with XL-520.

A paper presented at the 1956 meeting of the American Ceramic Society described the analytical techniques employed in determining the amount of XL-520 found in treated bottles. In brief, it is based on quantitative extraction of XL-520 from the bottle with benzene. An infra-red spectrum of the benzene extract is used to determine the quantity of XL-520. Data gained by this method prompted federal agencies to offer no objection to the use of XL-520 on food containers, under the application conditions described in the submittal.

XL-520 has been used to treat over 750,000 gross of bottles during the last 18 months. This type of surface

TABLE II

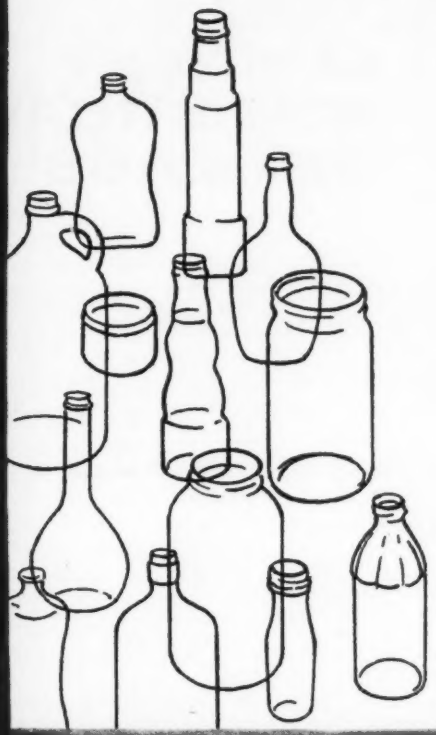
STATIC COEFFICIENTS OF FRICTION FOR SODA-LIME GLASS AGAINST SODA-LIME GLASS; LUBRICANT APPLIED AS A DILUTE, AQUEOUS SPRAY

Lubricant	Fs at room temp.
None	0.9
Vinylsilane	0.8
Water	0.65
Amylsilicone Polymer	0.4
XL-522 Organosilicone Fluid	0.3
LE-45 Dimethylsilicone	0.15
Silicone Containing Cilanic H	0.1
XL-520 Organosilicone Fluid	0.1

protection has been found desirable on beers, soft drinks, wine, whisky, baby food and many other types of containers. Many major packers and bottlers have given

(*Continued on page* 658)

progress
research
service
have made



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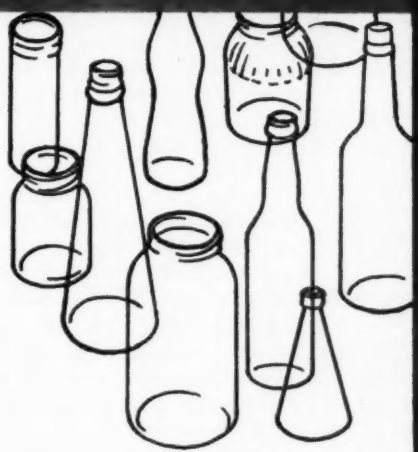


OVERMYER MOULD COMPANY, INC.
General office, plant and foundry, Winchester, Indiana.
Plants in Greensburg, Pennsylvania; South Gate, California

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during August, 1959, was as follows: *Flat Glass:* a preliminary figure of 28,400 for August, 1959, indicates a decrease of 1.4 per cent under the adjusted figure of 28,800 reported for July, 1959. *Glass and Glassware, Pressed and Blown:* a decrease of 2.3 per cent is shown by the preliminary figure of 83,700 reported for August, 1959, when compared with the adjusted figure of 85,700 reported for July, 1959. *Glass Products Made of Purchased Glass* the preliminary figure of 15,000 given for August, 1959 is an increase of 1.3 per cent over the adjusted figure of 14,800 reported for July, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	September, 1959
Food	1,659,000
Medicinal and Health Supplies	1,262,000
Chemical, Household and Industrial	953,000
Toiletries and Cosmetics	736,000
Beverage, Returnable	508,000
Beverage, Non-returnable	90,000
Beer, Returnable	141,000
Beer, Non-returnable	874,000
Liquor	948,000
Wine	341,000
Sub-total (Narrow)	7,512,000

Wide Mouth Containers

Food	*3,876,000
Medicinal and Health Supplies	362,000
Chemical, Household and Industrial	154,000
Toiletries and Cosmetics	142,000
Packers' Tumblers	33,000
Dairy Products	203,000
Sub-total (Wide)	*4,770,000
Total Domestic	12,282,000
Export Shipments	216,000
TOTAL SHIPMENTS	*12,498,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production September 1959	Stocks September 1959
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,397,000	5,148,000
	Wide Mouth	*4,115,000	*4,919,000
Beverage, Returnable		619,000	1,490,000
Beverage, Non-returnable		106,000	203,000
Beer, Returnable		177,000	319,000
Beer, Non-returnable		848,000	522,000
Liquor		1,007,000	1,010,000
Wine		338,000	484,000
Packers' Tumblers		30,000	101,000
Dairy Products		195,000	207,000
TOTAL		*11,832,000	*14,403,000

*This figure includes Fruit Jars and Jelly Glasses.

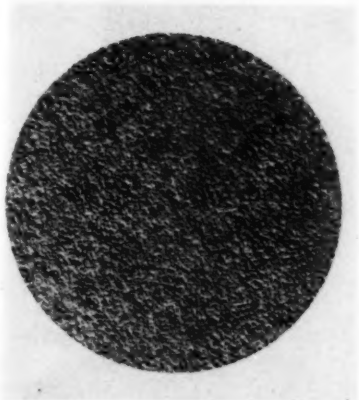
Payrolls in the glass industry during August, 1959, were as follows: *Flat Glass:* A decrease of 4.3 per cent is shown in the preliminary $15,791,930.48 given for August, 1959, when compared with July's $16,471,084.90. *Glass and Glassware, Pressed and Blown:* a decrease of 2.3 per cent is shown in the preliminary $32,205,282.48 reported for August, 1959, when compared with the previous month's adjusted $32,681,444.52. *Glass Products Made of Purchased Glass:* a preliminary figure of $4,735,535.70 was reported for August, 1959. This is an increase of 1.5 per cent when compared with the adjusted figure of $4,660,852.11 for July, 1959.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 11,832,000 gross during September 1959. This is a decrease of 20.8 per cent under the previous month's production figure of 14,944,000 gross. During September, 1958, glass container production was 12,583,000 gross, or 6.3 per cent over the September, 1959, figure. At the end of the first nine months of 1959, glass container manufacturers have produced a preliminary total of 116,264,000 gross. This is 6.3 per cent more than the 109,307,000 gross produced during the same period in 1958.

Glass Container Shipments during September, 1959, came to 12,498,000 gross, a decrease of 37 per cent under August, 1959. Shipments during September, 1958, amounted to 13,555,000 gross, or 8.4 per cent more than September, 1959. At the end of the first nine months of 1959, shipments have reached a preliminary total of 119,479,000 gross, which is 10.3 per cent more than the 108,255,000 gross shipped during the same period the previous year.

Stocks on hand at the end of September, 1959, came to 14,403,000 gross. This is 4.7 per cent less than the 15,120,000 gross on hand at the end of August, 1959, and 19.8 per cent less than the 17,971,000 gross on hand at the end of September, 1958.

NEW EQUIPMENT AND SUPPLIES



Zirconium Silicate Refractory

Harbison-Walker Refractories Co., has introduced a new high purity zirconium silicate refractory for paving glass tank bottoms and vulnerable parts of the superstructure above the glass line.

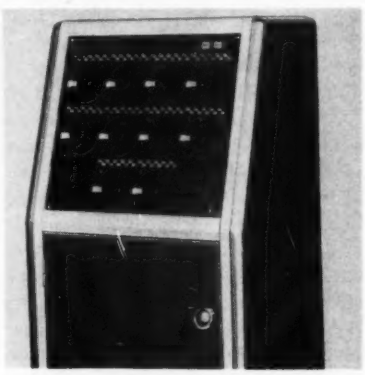
The refractory brick are impact pressed for uniform density, homogeneous texture, high compressive and transverse strength, and constancy of volume at temperatures ranging up to +2900° F.

Structural Gaskets

Inland Manufacturing Division, Dayton, O. has available a neoprene structural gasket said to provide a simple, positive leakproof setting member for use with ribbon windows, separate or continuous sash, windows in combination with insulated panels, and curtain walls. It can be used as the setting member for glass with glass, glass with metal or any other material with a durable surface. The gasket eliminates all mitered corners and joints by injection molding of all angles. It gives a permanent constant pressure on the sealing edges for the full perimeter of the opening. The gaskets can be used with ⅛ in., ¼ in., ½ in., 1 in., and 2 in. thicknesses of glass. The neoprene permits freedom of movement with the building; expansion or contraction will not deteriorate the gasket. Glass, panels or other units can be installed from inside or outside. Ignition temperature is 650° F.

Temperature Alarm Readout

Fischer & Porter Co., Hatboro, Pa., has introduced a simultaneous temperature alarm readout that monitors up to 100 temperature points, depending upon the number of 10-unit panels it contains. It is so designed that when one of the temperature points being sensed reaches the temperature indicated on its control dial an alarm is sounded, and the critical point is identified by a numbered light on the control panel.



The machine provides direct readings on the Fahrenheit scale with an overall accuracy of plus or minus 3° F. The unit is completely transistorized. The audible alarm can be turned off by a reset push button, while the identifying light remains on as long as the temperature is off-normal. The actual temperature of any point, normal or off-normal, may be determined by depressing the quiet button then manually rotating the appropriate set point dial until the numbered light flashes on. Total weight is 125 pounds.

Fused Silica

Corning Glass Works, Corning, N. Y., has developed a technique for forming high purity fused silica into a wide variety of shapes and in sizes said to be equal to any achieved by conventional ceramic forming processes. The material is said to withstand long-term use at temperatures over 1700° F and intermittent use to 2250° F. The softening point is 2880° F and the coefficient of thermal expansion is 3×10^{-7} per degree F. The dielectric constant at a frequency of 8.6×10^{9} cps is 3.58 at 77° F and 3.57 at 750° F. The dielectric loss factor at the same frequency ranges from .00069 at 77° F to .00098 at 750° F.

The silica has a porosity of 9 to 13.6 per cent, a density of 1.9 to 2 grams per cubic centimeter and it can be machined to tolerances of plus or minus .001 inch.

Vibrator

Martin Engineering Co., Neponset, Ill., has produced a vibrator with quick clamp mounts for portability of the machine. The device operates on 115 v. a.c.-d.c. through a rheostat and has a stepless speed control from 2,000 to 10,000 vpm. The electrical parts are fully enclosed and the unit has forced air cooling.

HOMMEL

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. . . with a series of new color squeegee machines paving the way for today's applied ceramic labels and decorative glassware industries.

PIONEERING NEW CERAMIC VISTAS

HOMMEL

Temperature Controller

Minneapolis-Honeywell Regulator Co., has introduced an indicating temperature Controller for service in industrial heating and cooling operations, at temperatures between minus 50° and plus 1200° F. The device has a load rating of 62.5 VA at 115/230 volts, a.c.

Fluorspar

Minerva Co., Elizabethtown, Ill., has available special sizings of fluorspar, other than standard, which can be produced in either the acid or ceramic grades. Chemical and screen analyses are made on shipments to control specifications requiring low iron, lead, barite, sulphur, organics and other contaminants.

Stopcock Plugs

Kimble Glass Co., Toledo, O., has available stopcock plugs said to be impervious to any known solvent which could swell or dissolve the polymer at temperatures below 300° C. The handle has a built-in grip for easy turning and an exaggerated taper and polished barrel that prevents binding and provides a permanent, tight, no-leak seal.

Oscillograph

Minneapolis-Honeywell's Heiland Division has introduced a direct-recording oscillograph which is the lowest in cost-per-channel of the company's Visicorder line. Designed to allow high-speed recording of up to 24 channels of scientific and test data simultaneously. Pushbutton chart speeds are adjustable in 15 variations from .05 to 80 inches per second. Produces instantly-readable records without the use of powders, inks, styli, heat, electrostatic charge, liquids, vapors or other chemical or darkroom processing.

Lead Impregnated Glass Fabric

Cordo Chemical Corp., Norwalk, Conn., is manufacturing a lead powder impregnated woven glass fabric or vinyl coated cotton duck which combines the acoustical properties of lead, high decibel lowering per pound, with the strength-flexibility characteristics of glass, vinyl or cotton. It can be employed for aprons or wall covering in X-ray work.

It is available in weights varying from 0.25 to as high as 1.75 pounds per sq. ft., where a transmission loss from 5 decibels at 100 cycles to 60 decibels plus at 13,000 cycles or more can be realized.

HOMMEL

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. . . with hot squeegee electrically heated screens to retain thermo-paste workability for fast, non-smear application.

PIONEERING NEW CERAMIC VISTAS

HOMMEL

CATALOGS RECEIVED

Silicone products. (8 pages) Major uses, including mold release agents and surface coatings for glass.
GENERAL ELECTRIC, Waterford, N.Y.

Grinding and grinding wheels. (15 pages) Fiftieth anniversary issue of Grits and Grinds, a technical magazine of grinding, lapping and surface finishing.

NORTON CO., Worcester, Mass.

Lift truck advances; (24 pages) Booklet describes safety and economy features, construction, operating efficiency, handling ease and driver comfort in 3 different gasoline, diesel and LP gas-powered lift trucks with lifting capacities ranging from 2000 to 4000 lbs. Illustrated.
TOWMOTOR CORP., Cleveland, Ohio.

Diamond coated steel tools. Catalog with reprints of articles describing use of diamond coated tools including saws, wheels, drills, burrs, edgers, shapers, hole saws, band saw blades, countersinks and others in machining and sawing glass-reinforced plastics, glass cloth laminates, pyrex and optical glass. Illustrated.
DIA-CHROME CO., Glendale, Calif.

Lighting predictor. (28 pages) Describes a prediction technique to aid architects and illuminating engineers in calculating maximum advantages of use of natural daylight. Based on over 2,000 lighting tests in different rooms with approximately 500,000 illumination values and involving more than a million computations. Contains technical papers approved by the Illuminating Engineering Society. Includes six basic principles formed from a 10-year study. Short review of terminology and fundamentals of daylighting; discussion on the availability of daylight including daylight distribution and the conditions which affect it; and demonstration of the application of the prediction technique as applied to nine typical situations are listed in three sections. Tables of coefficients of utilization, factors which express numerically the effects of physical conditions on daylight distribution, and curves and tables for determining exterior or daylight conditions are given.

LIBBEY-OWENS-FORD GLASS CO., Toledo, O.

. . . and **HOMMEL**

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. . . with a glass color meeting—and surpassing— the demanding resistance specifications for Corning's glass dinnerware . . . affording new expansion in their institutional dinnerware growth. Hommel's 68 years of pioneering research and painstaking quality control continues to develop new and better frits, glazes and colors for the ceramic industry's expanding needs. Quality materials that create actual production savings are yours when you specify Hommel.

PIONEERING NEW CERAMIC VISTAS

THE O. HOMMEL CO.

PITTSBURGH 30, PENNSYLVANIA

WEST COAST—4747 EAST 49th STREET, LOS ANGELES

Automatic weighing systems. (23 pages) Describes the instrumental technique of automatic weighing in terms of its basic components. Includes a variety of weighing structures, electric and pneumatic weight transmitters, and readout devices such as indicators, recorders, totalizers and digitizers. Contains information on unitized control system components responsive to the signal from the weight transmitters. In batch weighing systems the components range from simple dump and fill controls to units capable of programming, filling, weighing and dumping a given number of material batches.

Continuous weighing systems include units for controlling, proportioning, and programming the rate of material flow. Typical automatic process control applications are given and control capability of weighing systems is shown in an illustrated chart of major components.

WEIGHING & CONTROL COMPONENTS, INC., Hatboro, Pa.

Recording instruments. (12 pages) Bulletin providing buying information on line of recording instruments. Includes dimensions and chart speeds, operating specifications, applications, features and accessories. In color with photographs. Describes specialized recording instruments available, such as spectrophotometers, recording vibrometers, automatic oscillographs, self-balancing potentiometers, and speed recording systems.

GENERAL ELECTRIC CO., Schenectady, N. Y.

Industrial trucks. (6 pages) Folder describes and illustrates rider-type electric and gasoline powered fork trucks, side-loading traveloader, which is gas, electric, L. P. or diesel operated, electric platform trucks and electric crane trucks.

BAKER INDUSTRIAL TRUCKS, Cleveland, O.

Capacity chart. Revised version of interrupting capacity chart that describes the correct circuit breakers for user's applications. Includes newly-designed breakers; JK, JKL and four Mark 75's.

WESTINGHOUSE ELECTRIC CORP., Pittsburgh, Pa.

Palletizing manual. (44 pages) Revised edition describing recommended equipment and procedures for the palletized loading and shipment of all types of refractory products. Detailed drawings and charts.

REFRATORIES INSTITUTE, Pittsburgh, Pa.

Annunciator systems. (52 pages) Catalog describes function and application of annunciator systems. Twelve systems are included with mechanical and engineering data, illustrations, charts and diagrams. Descriptions and data on components and related equipment are also given.

PANELLIT, INC., Skokie, Ill.

Stationary air compressor. (24 pages) Bulletin gives specifications, diagrams, cross section drawings and installation photographs for WN-112 stationary air compressor.

JOY MFG. CO., Pittsburgh, Pa.

Bronzeless gold spray finishes. (8 pages) Contains information on bronzeless gold spray finishes said to be non-tarnishing, and non-gelling. Includes chips of standard colors available.

BEE CHEMICAL CO., Chicago, Ill.

LIME

For Over 50 Years Gibsonburg Ground Burnt Fluxing Lime Has Been the Choice of the Glass Industry

Gibsonburg E-Z FLO

Ground Burned Fluxing Lime

Always Uniform in composition because . . .

1. It is made from the world's purest dolomitic limestone.
2. It is burned and processed in the cleanest, most modern plants in the industry.
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4. When taken out of kilns it is ground, screened and immediately loaded into cars for shipment assuring low ignition loss.
5. Dependable Deliveries.

John C. Denison and Son, Agent
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THE GIBSONBURG LIME PRODUCTS CO.
GIBSONBURG, OHIO
Phone 3421

INVENTIONS AND INVENTORS

Annealing and Tempering

Glass Container Inspecting Apparatus. Patent No. 2,890,736. Filed October 22, 1957. Issued June 16, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Wallace W. Wolford.

There is shown in conjunction with container inspecting apparatus comprising a series of cradles supported on endless carriers which bring the cradles in succession to inspecting stations at each of which the cradles are held stationary momentarily while bottles or jars resting thereupon are inspected for certain detectable defects. The bottles occupy recumbent positions in the cradles and are rotatable freely therein about their axes. At one station the bottles or jars may be inspected to determine whether the neck is circular within certain limits and concentric with the body portion. At another station an electronic device may function to detect imperfections in annular areas of the bottom and adjacent areas of the side wall. Both of these inspections require rotation of the bottle or jar about its own axis and such must be fairly rapid if the inspecting step is to keep pace with normal production speeds.

Means for effecting such rotation of the bottles or jars comprises a turbine-type air motor which carries and drives a roll. This roll is designed for driving contact with a peripheral portion of the bottle or jar body to impart rapid rotary motion thereto. Air under pressure is supplied to the motor. Both the motor and roll are movable between vertically spaced positions in the lower of which the roll has driving contact with the bottle or jar.

There were three claims and the following references cited in this patent.

United States Patents

2,577,341, Magnusson, Dec. 4, 1951; 2,639,830, Weimont, May 26, 1953.

Feeding and Forming

Reshaping hot glass by high pressure air jets. Patent No. 2,888,780. Filed August 24, 1956. Issued June 2, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Wolfe Bode.

In practicing the invention a funnel body or other workpiece which is to have its sealing edge reformed is placed over a shaping block with the rim surface of the block in contact with the inner rim surface of the workpiece. The block and workpiece are then rotated about a vertical axis while a burner flame or flames are directed against the exterior surface of the rim for softening the glass. When the glass is in a softened condition a high velocity jet or jets of air or other gas are directed against the said outer rim surface, thereby reshaping the rim to conform to the shape of the opposite surface of the shaping block.

The workpiece is preferably preheated to a temperature of 600 to 750° F. before placing it on the reshaping apparatus. The burner jet or jets are then applied to the rim of the rotating workpiece to further raise the temperature and soften the glass. When this temperature, from 1200 to 1400° F. is reached, the air blast is turned on and thereby reshapes the rim of the article, the flame jets and air jet or jets operating concurrrently. When the reshaping operation is completed and the air blast is turned off the burner flames are continued for a short time, a few seconds, for annealing the reshaped glass. The invention provides an automatic control system for controlling application of the heating and air pressure jets in the proper order and times relation during the heating and reshaping operations.

There were 7 claims and the following references cited in this patent.

United States Patents

1,482,789, Gmelin, Feb. 5, 1924; 2,106,193, Sloan, Jan. 25, 1938; 2,152,754, Wagner, Apr. 4, 1939; 2,427,722, Greiner, Jan. 17, 1950; 2,580,450, Melcher et al., Jan. 1, 1952; 2,661,216, Snow et al., Sept. 23, 1952.

Foreign Patent

339,503, Germany, Aug. 9, 1919.

Furnaces

Apparatus for conditioning molten glass. Patent No. 2,884,744. Filed February 23, 1956. Issued May 5, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Joseph R. Monks, Jr.

The present invention is an apparatus for conditioning molten glass preparatory to delivering measured mold charges of the same to the molds of ware forming machines by means of a flow feeder.

Gas is introduced in the form of bubbles at a prescribed though variable rate, through conduits which extend upwardly through the floor at points in very close proximity to the wall of the furnace.

These conduits may vary in number and be arranged either in a straight line extending transverse to the length of the forehearth extension or "feeder boot", or in a generally arcuate pattern. In either event, the conduits are so positioned relative to each other as to provide a vertical curtain-like zone of upwardly moving glass which will insure complete dispersion of the lumps and particles of refractory materials. Moreover, the

conduits are so distributed as to create a zone of upwardly moving glass which, in length, is substantially equal to the width of the corresponding "feeder boot."

For the purpose of supplying air or gas under pressure to the conduits or bubbler tubes, the latter are connected to a source of air or gas under pressure by means of a plurality of pipes leading to a corresponding number of constant pressure differential regulators, the latter being carried by a manifold.

This manifold is connected through a pipeline and suitable filters to a reserve air tank the latter in turn being directly connected to the supply source.

With this arrangement, it is obvious that any suitable gas may be utilized to produce the bubbles which cause agitation of the glass and dispersal of the lumps of refractory material, etc. and that the pressure and rate of flow may be regularly controlled to determine for example, the number of bubbles per minute and therefore the intensity of the agitating or mixing action.

There was one claim and the following references cited in this patent.

United States Patents

2,026,287, Stenhouse, Dec. 31, 1935; 2,063,842, Honiss, Dec. 8, 1936; 2,115,408, Brosse, Apr. 26, 1938; 2,263,549, Peyches, Nov. 18, 1941; 2,331,052, Shadduck, Oct. 5, 1943; 2,387,222, Wright, Oct. 16, 1945; 2,710,306. Penberthy, June 7, 1955.

Foreign Patents

486,200, Germany, Oct. 31, 1929.

Water cooled skimmer for glass furnace forehearth. Patent No. 2,888,781. Filed August 30, 1955. Issued June 2, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by George L. Fraser.

Glass flows from the tank at a high temperature into a forehearth or channel and during its flow through the channel the temperature is regulated and controlled, the temperature being materially reduced to the required degree for molding purposes. The capacity of the forehearth, or more specifically the rate of flow and amount of glass that can be transmitted through the forehearth in a given length of time, depends upon the rate at which the glass can be cooled while control of the temperature is maintained.

A heat extracting device referred to as a skimmer, comprises a water cooled tube which may be an "Inconel" tube or other metal pipe through which a continuous flow of water or other fluid coolant is maintained. This cooling device comprises vertically disposed pipe sections which may be uniformity spaced transversely of the well. said sections united by U-shaped portions thereby providing a zig-zag or tortuous path for the flow of the fluid coolant. The cooling device is only partially immersed in the glass and may be adjusted vertically to extend to any desired depth. The pipe sections are spaced to permit a portion of the glass to flow between while an additional portion flows beneath the pipe, or water cooled dam. The device functions as a skimmer as well as a cooling unit.

There was 1 claim and 10 references cited in this patent.

Apparatus for the Method of Making Glass. Patent No. 2,890,547. Filed November 10, 1951. Issued June 16, 1959. No sheets of drawings; none reproduced. Assigned to Emhart Manufacturing Company by Aaron K. Lyle.

The invention provides a long, narrow horizontal furnace chamber or channel having a ratio of length to width far in excess of that of the existing large capacity furnaces; and a total length of melting and refining zones correspondingly greater. These features would bring about a substantial increase rather than decrease of fuel consumption per ton of glass produced if the firing and batch charging provisions and practices of the prior art were employed. However, they also afford a basis for adequate saving when the firing provisions and operations of the present invention are used. These comprise adjustable fuel burners located at appropriate intervals along each side wall of the furnace channel and operation thereof to effect input to the forward or fining zone of the greater part of the total fuel input, a place of maximum temperature, i.e., the so-called "hot spot," at a location well forward in the fining zone, and a lower temperature downgradient rearwardly from the hot spot to the charging end of the channel where a stack is provided to exhaust the waste products of combustion and gases.

The invention also provides for charging of the batch with an attendant forward impelling action on the supporting glass so as to overcome the tendency toward a rearward convection current and to create instead a forward surface movement of the glass effective to advance the charged batch and supporting glass for the desired batch melting action and so as to permit batch charging at a satisfactory rate.

There were 4 claims and 11 references cited in this patent.

Sheet and Plate Glass

Sealing means for glazing unit. Patent No. 2,887,738. Filed July 12, 1954. Issued May 26, 1959. No sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Frank R. Prescott and William R. Bauer.

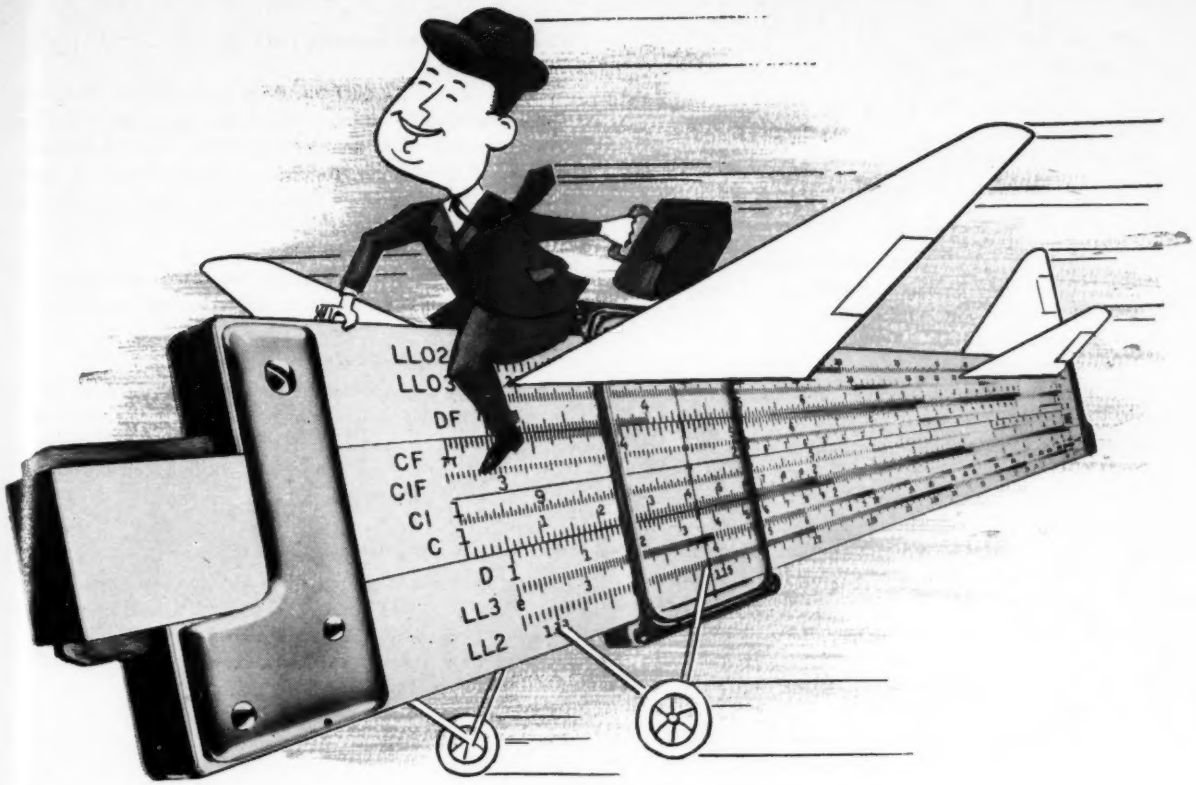
This invention relates to an improvement in multiple glazed units that comprise at least two spaced sheets of glass that are united around their peripheries by a peripheral strip. In particular, this invention relates to improved pore opening seals to be used in conjunction with such assemblies.

This seal may take various forms, but each embodiment of the present invention is characterized by a seal located in a recessed position with respect to the outer surface of the sheet of glass containing the pore opening. This recessing has been accomplished both by providing a specially designed recessed aperture for maintaining the seal in a desired location and also by designing a seal capable of being maintained in a recessed position within a pore hole. Such seal comprises an element having an opening therein which is more easily sealed than the pore opening in the glass itself.

There were 4 claims and the following references cited in this patent.

United States Patents

2,683,906, Nevins, July 20, 1954; 2,686,342, D'Eustachio, Aug. 17, 1954; 2,689,924, Honing et al., Sept. 21, 1954; 2,749,579, Shaw, June 12, 1956.



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COLOR ON GLASS

(*Continued from page* 591)

For structural glass, where the primary consideration is weather resistance, it has been found that acid-resistant colors serve best.

Coefficient of Expansion

Perhaps the most difficult specification the glass color manufacturer has to meet is coefficient of expansion, especially if the enamel must have high durability and low firing temperature.

When decorated glass is heated and cooled, both the glass and the enamel expand and contract. It is extremely important that this expansion and contraction of the glass and enamel be such that no stress will develop which will adversely affect the strength of the glass.

As a general rule it can be said that an enamel, to have a good fit to the glass, should have an expansion of not less than 3 x 10^{-7}°C. lower than the expansion of the glass itself. For example, if a glass has a coefficient of expansion of 81 x 10^{-7}°C., then the enamel to be used on the glass should have an expansion of 78 x 10^{-7}°C., or less. If the expansion of the enamel is less than this, an improvement in both the thermal and mechanical strength of the glass will be noted.

Just how much lower the coefficient of the enamel can be than the glass has not been determined. In one particular case, where enamels with a coefficient of expansion of 57 x 10^{-7}°C. were applied to glass with an expansion of 81 x 10^{-7}°C., the decorated ware was fired through a tempering kiln and then subjected to severe thermal shock as a part of the production process.

With the expansion of the enamel at 57 x 10^{-7}°C. and the glass at 81 x 10^{-7}°C., the results from the standpoint of thermal and mechanical strength were perfect. Previously, an enamel with a coefficient of 78 x 10^{-7}°C. applied to the same glass had given trouble with thermal breakage.

On the other hand, when the expansion of the enamel is greater than the expansion of the glass on which it is applied, the strength of the glass will be diminished. If by actual measurement the expansion of the enamel is just equal to the expansion of the glass, there will be a discernible weakening of the glass. When the expansion of the enamel is raised to the place that it is 10 x 10^{-7}°C. higher than the expansion of the glass, spontaneous crazing of the enamel will occur and, in many cases, the glass will break as a result of excessive tension stress in the enamel.

It is a good rule to remember that the enamel functions as the outside surface of the glass, so that whatever happens to the enamel automatically happens to the glass on which it is applied.

When borosilicate glasses are decorated with ordinary glass enamels the expansion differential between the enamel and the glass is usually great. In many cases it will exceed 40 x 10^{-7}°C. In these cases a very fine type of crazing develops in the enamel, and very shortly these crazes join each other immediately under the enamel surface. The stress in the glass is relieved enough so that borosilicate glasses are not as seriously weakened as a soda-lime glass would be if it were decorated with an enamel having an expansion of only 10 x 10^{-7}°C. greater than the glass.

Much time and effort has been expended on the problem of developing enamels which are satisfactory for the low-expansion glasses; much progress has been made. Today, it is possible to make a good range of glass enamels, for borosilicate glasses, which have a coefficient of expansion of approximately 45 x 10^{-7}°C. and a firing temperature of about 1160°F.

The problem of decorating the very low-expansion borosilicate glasses, however, still remains unsolved.

Melting Temperatures

Since they are applied to articles of preformed glass, all glass enamels must have a melting temperature far enough below the softening point of the glass so that they can be fired to a good gloss without causing deformation of the glass.

Working Characteristics

Glass enamels are supplied as powder, squeegee paste, thermoplastic solids or in a vehicle consisting essentially of alcohol and water. When enamels and oils are mixed together they exhibit a certain tendency to produce a slurry which will flow.

If this paste flows excessively it is said to be "fat," and if it has little or no flow it is "short." Extremely short working paste leaves screen marks in the print which are usually regarded as objectionable. Extremely fat working pastes tend to run through the mesh of the screen and frequently will run or sag when applied to the glass.

These same comments also apply to spray enamels. With a fat spray enamel, it is almost impossible to get a good application of color without having some running and sagging on the ware. On the other hand, if the color works extremely short the finish tends to be rough and pock-marked.

It is the usual object of the glass enamel manufacturer to produce a paste which:

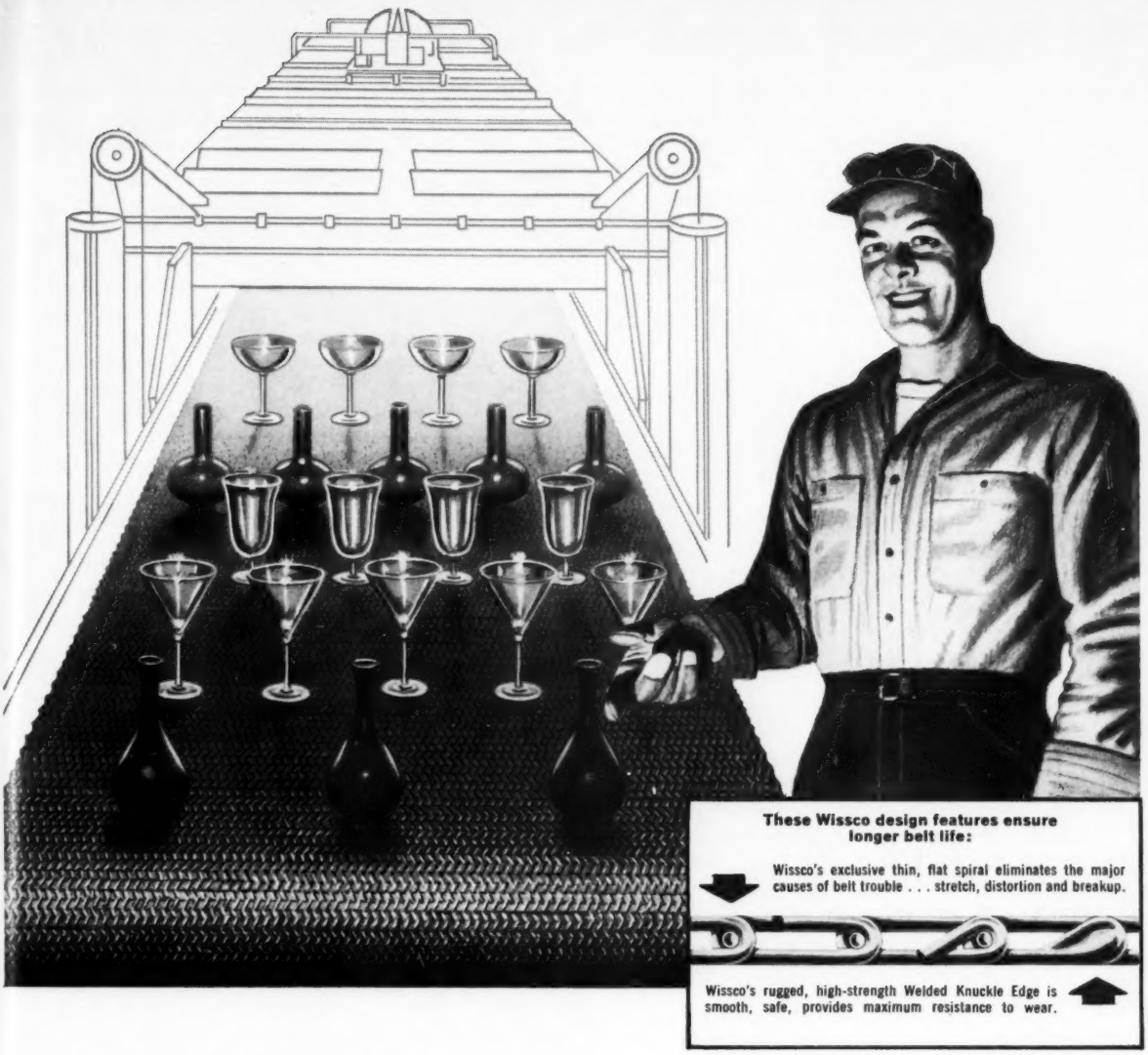
1. Will flow sufficiently well to level screen marks.
2. Will not flow so well as to cause running or sagging.
3. Will have a sufficient degree of shortness so that it will produce sharp, well-defined prints.

Firing

The perfect glass enamel has not yet been produced. However, glass enamels have been brought to a high degree of development so that today enamels of outstanding quality are available, and their quality is uniform.

Perhaps the largest single source of trouble encountered in the utilization of glass enamels is in their firing, and by far the most important part of the firing is in the preheat zone of the lehr. For best results a lehr should be equipped with a sufficient number of burners in the preheat zone so that the temperature just under the door can be varied from 100°F. to as high as 900°F.

Sufficient ventilation should be provided so that squeegee oil solvents and decomposition products of the resins in the oils can be carried away rapidly. When a glass enamel enters the preheat zone of the lehr, solvents contained in the printing vehicle are vaporized. As the temperature rises, decomposition of the resinous portion of the oil occurs. Sufficient oxygen must be present so that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the decomposition products can be oxidized to a gaseous state and carried away.

A good rule to follow is to have the ware enter the lehr at the highest temperature it will stand without breakage, then carry the temperature up as rapidly as possible to a point just under the fusing temperature of the enamel. At this temperature, which is usually about 800°F. to 850°F., the temperature is leveled out for a period of five to ten minutes.

After this preheat, the temperature is again carried up as rapidly as possible to firing temperature. It is held at firing temperature for a period of from five to twelve minutes. The temperature is then allowed to decline at a rate slow enough to permit good annealing.

While the ware is passing through the preheat zone of the lehr and the temperature is being raised, it is also necessary to provide air to carry away oil vapor and provide oxygen for the oxidation of the heavier portions of the printing vehicle.

It is surprising how frequently a condition is encountered in the preheat zone of the lehr which could best be described as an "equilibrium condition;" i.e., oils are being vaporized from the surface of the color and at the same time they are recondensing on the ware. This causes thin, light streaks of color to travel out from the edges of the prints, giving them a feathery appearance. If the condition is severe, areas will be observed where the oils have actually trickled down the side of the ware, carrying with them minor amounts of color.

Sweating is another condition which can be seriously aggravated if ventilation is not sufficient. When cold ware is decorated it will sweat excessively as it enters the warm zone of the lehr. It is a common occurrence to have ware sweat so badly that printed matter on the glass will actually slip. Where this condition is severe it will be necessary to preheat the ware before decorating, but in mild cases it can be overcome simply with good ventilation.

The principal purpose of the preheat zone of the lehr is to distill off and burn away all of the organic material contained in the color before fusion occurs, and to condition the glass for the high temperature of the fire box. If the flux in the color melts before all the vehicle is removed, then either blistering or carbon retention will result. If the color blisters, it can be readily detected by scraping with a sharp knife. In some rare cases carbon will be retained in the color without blistering, and in these cases the color simply appears dark.

A wide variety of squeegee oils are available. They have different burnout characteristics so that an oil can usually be selected which will give best results under the conditions of operation which prevail. If preheating has been properly handled, the work performed in the firing zone of the lehr becomes a rather easy routine.

NATIONAL BUREAU OF STANDARDS

(*Continued from page* 590)

of the batches from which the glasses are melted. While the method has been used only on a laboratory scale, it appears to be usable on melts of any size.

Data on the refractive indices of 13 optical glasses and 30 experimental glasses have been obtained over the wavelength range from 0.43 to 4.25 μ in cooperation with personnel at Eastman Kodak Company.

Standard Sample Program

The Bureau has for a number of years had available standard samples of glass which were used as checks on the accuracy of chemical analysis of glass. We have now undertaken to make available two additional types of standard samples. One will be a series of glasses, representative of important commercial types, that can be used for calibration and standardization of instruments used in measuring the properties of glass. The second series will be simple glasses of high purity containing one, two or three components that can be used for comparing results between laboratories, especially in studies of structure and constitution.

For standardizing measurements of glass properties, the viscosity of a soda-lime-silica glass is now being measured at temperatures up to 1450°C. A rotating cylinder type viscometer has been built and calibrated with standard oils and is being used to measure the viscosity at the higher temperatures. In the lower temperature range the viscosity and softening point are being determined by the fiber elongation method. The surface tension of this glass will also be determined over a wide temperature range. Later, additional glasses representative of commercial types will be calibrated for viscosity and surface tension standards.

High-Temperature Viscosity and Surface Tension

In addition to the viscosity work in connection with the standard glass, we are attempting to develop methods of measuring viscosity and surface tension that can be used at high temperatures, possibly above 2000°C. Such data on liquids at high temperatures are necessary both to advance technology and for progress in fundamental scientific understanding. So far, the work has progressed only to the point of building a low-temperature model of an oscillating-cup viscometer, and calibrating the device at low temperatures with oils of suitable viscosity. It is believed that the same design principle can be used to build a device suitable for tests at high temperature. The apparent advantage of the oscillating-cup viscometer for very high-temperature work is that liquids under investigation can be in a totally enclosed container while the rest of the system is in a vacuum. Also, the cup containing the molten material is of a simple geometric shape so that it can be easily fabricated if frequent replacement is necessary. The first material scheduled for study at high temperatures is B_2O_3.

Strength of Glass at Elevated Temperatures

With the increasing speed of aircraft, serious consideration must be given to the elevated-temperature properties of transparent glazing materials. As the operating temperatures approach the useful working limit of the glass, and the possibility of rapid changes in temperature brings concern regarding the ability of the glass to withstand thermal shock, many serious engineering problems are created. There is, of course, much useful information

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in the literature on the properties of glass. However, the application of this information to specific problems of glazing aircraft enclosures would require extrapolation and interpretations that are highly questionable in the light of our present knowledge. The actual testing of specimens under conditions approaching those of contemplated use seems indicated.

For this reason, the Wright Air Development Center initiated a study which has as its objective the collection of data on the properties of flat glass specimens from room temperature to temperatures near the softening point of glass. The part of this program that pertains to determination of the mechanical properties of glass is being carried on largely at the National Bureau of Standards but with the assistance and cooperation of the Materials Laboratory of the Wright Air Development Center and of three glass companies: Libbey-Owens-Ford Co., Corning Glass Works, Pittsburgh Plate Glass Co.

A limited number of glasses were chosen for study. Consideration was given only to glasses that are available in commercial quantities, or glasses that have been produced in at least pilot plant quantities in the form of polished plate. The study does not include work on the development of new glass compositions for aircraft use. Although the glasses selected for study are few in number they do cover a rather wide range of physical properties, particularly in respect to coefficient of expansion and strain point.

A study of test methods and methods of sample preparation has been completed. The strength tests on six types of glass (soda-lime-silica, 2 borosilicates, alumino silicate, 96 per cent silica, and fused silica) are almost complete and the results to date have been included in a series of reports to the Air Force. Samples of glass with varying degrees of temper have been included in the study to determine the rate at which the strength of tempered glass changed when held at elevated temperatures. The same series of glasses are also being used for creep-rupture tests and measurements of modulus of elasticity at various temperatures.

Conclusion

The work now underway at the National Bureau of Standards should contribute to a more complete understanding of the complex structure of glass and provide data essential to the sound engineering design of glass for various applications. When the nature of the glass structure is better understood it should be possible to design glasses having specific optical, mechanical or thermal properties with less expenditure of effort in the making of large numbers of experimental melts.

RESEARCH AND GLASS FURNACE REFRACTORIES

(*Continued from page* 593)

Laboratory furnaces were developed to simulate the regenerative cycling effect, both atmospheric and temperature. With the accelerated conditions, it was possible to develop new basic refractories which displayed remarkable resistance (Figs. 4 and 5) to this cyclic effect. Today, basic refractories are available which can endure prolonged cycling and still retain good resistance to chemical attack by the volatile components in the gases.

The present problem existing in regenerator refractories involves the actual physical properties of the condensed volatiles themselves. Laboratory studies are constantly being made with the aim of obtaining a better understanding of the behavior of these condensates on various types of refractories.

Monolithic refractory materials are finding wider acceptance for use in glass furnace construction. Refractory castable materials are now considered standard for the construction of glass furnace flue arches in some plants, and are being used experimentally for rider arches in others. The low permeability of these materials may make them especially suitable for those locations in the glass furnace where resistance to attack by condensates is so important.

The application of refractories by gunning has proved itself an economical method of repairing refractory walls in other industries, and service trials of this type of patching in glass furnace regenerator housings are now underway. Recently developed basic gunning materials are most promising for this application (Figs. 6 and 7).

The need for improved glass-contact refractories is apparent. Recent developments in the field of refractories for non-ferrous metals indicate that in exceptional cases it is possible to produce refractory materials which are resistant to wetting by specific molten liquids. While a goal of this nature seems wholly out of reach for the glass furnace, the importance of the problem justifies an imaginative approach.

GLASS IN THE NUCLEAR AGE

(*Continued from page* 595)

of components, and once begun, it is extremely undesirable and sometimes impossible to interrupt analytical processes, all glass components built for replacement on the equipment must be interchangeable. In order to insure this complete interchangeability, critical tolerances of up to ±0.0005″ must frequently be held during manufacture for mating parts or clearances. This tolerance is difficult to achieve in hand-worked glass, and is not often required in chemical laboratory apparatus.

As another phase of its activities, the KAPL glass shop is frequently required to fabricate and assemble complete and partial reactor coolant system mock-ups used to verify predicted coolant paths in proposed reactor coolant circulatory systems. Operation of the mock-up shows convection currents and other factors affecting coolant flow, and points out potential "hot spots" where stagnant water is collecting in the coolant system. When completed, the entire assembly is mounted in a simulated reactor hull section which is in turn gimbel mounted to reproduce the rocking motion of the ocean. This particular assembly (Fig. 4) was used to test the effect of the rocking motion on the circulating reactor coolant.

The coolant used in the reactor mock-up circulating systems is usually simulated by water or air, depending on the nature of the test; dyes or other types of tracers

(*Continued on page* 656)

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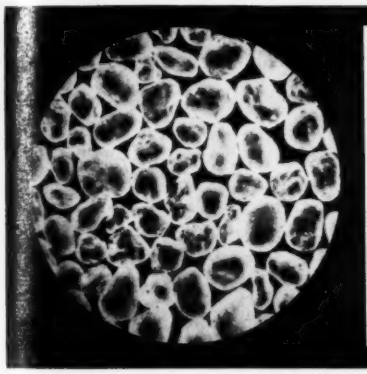

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Recorder Survey: Recording Surfaces and Marking Methods, National Bureau of Standards Circular 601, *by George Keinath,* 41 pages, (1959), 30 cents. Order from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

This publication deals with marking methods and recording surfaces and surveys and compares the characteristics of continuous traces, dotted traces, and printed characters produced by inking, incision, impression, indentation, deposition, heat, light, electric discharge, electron beam, magnetism, chemical action, or fluid streamlines.

The descriptive and reference materials include three physical components of the recording system, the reservoir of material or energy, the marking point or matrix positioned by the measuring element, and the chart surface which preserves the record.

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Vector Space and Its Application in Crystal-Structure Investigation, *by Martin J. Buerger,* John Wiley & Sons, Inc. 367 pages; $12.

Strictly speaking, Professor Buerger's book concerns neither vectors nor space in the mathematical sense. Rather, it is devoted to the application of various functions of the squared Fourier coefficients derived from X-ray diffraction experiments to the problem of locating atoms in the crystals studied in these experiments. It is thus a book on the physics of X-rays and crystals and represents the third of an excellent series of texts on this field, the first two being *Elementary Crystallography* and *X-Ray Crystallography* by the same author.

Familiarity with Fourier coefficients, space group notation, and the other terminology of X-ray crystallography, which may be obtained from the two introductory texts just mentioned, is presumed in *Vector Space.*

The first seven chapters of the book are devoted to the Patterson function and to various special devices by which the solution of crystal structures may be facilitated. Sharp F's, the difference Patterson and Patterson projections of symmetrical crystals are considered. In chapter 7, Harker sections and implication theory are treated, with the analyses of the structures of nepheline and tournaline as examples.

In chapter 8 a general study of sets of discrete points and their vector sets is initiated. Given a set of points a, b, c . . . in ordinary "crystal" space, the directed magnitude extending from point p to point q is defined as the vector $\vec{pq}$. If all of the vectors constructed for the fundamental set of points a, b, c . . . are shifted to have a common origin, the vectors are said to exist in "vector space." The point at the end of vector $\vec{pq}$ in vector space is designated pq and is regarded as a kind of product of p and q, the two points in the fundamental set. Since $\vec{pq} \neq \vec{qp}$, pq ≠ qp and multiplication is not permutative.

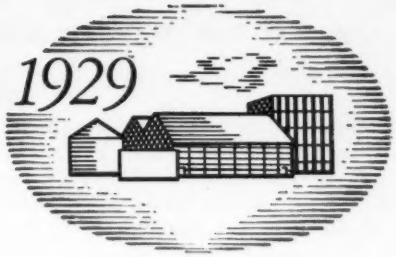
Chapter 9 develops the relationship between crystal symmetry and symmetry in vector space.

Image seeking functions and superposition functions are treated in chapters 10 and 11. In chapter 12 and 13 the use of image seeking functions in projections and in three dimensions is explained and illustrated by analyses of the structures of claudetite (As_2O_3) and diglycine hydrochloride. Coesite, the dense form of silica, is solved in chapter 13. Substructures are discussed in chapter 14 with spinel and pectolite as examples.

Chapter 15 is best summarized in the author's own words:

> "The reader of this book has been exposed to a wealth of detail in vector-space theory and its application in the investigation of crystal structures. He is presumably in a position to appreciate some of the broader features of the subject. This last chapter is an attempt to sketch some highlights, create perspective, and draw a few conclusions.

TODAY *as in 1929*



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GLASS IN THE NUCLEAR AGE

(*Continued from page* 652)

are used to show the circulatory path.

Special glassware is also fabricated for the production of single- and triple-distilled sodium, and for filling various types of irradiation assemblies with sodium and potassium-sodium mixtures.

Pure sodium and sodium-potassium mixtures are distilled in glassware especially fabricated for this purpose but of relatively conventional design and materials. No special seals are required in the glassware; conventional materials and seals are used, and distillation takes place in a relatively high vacuum (10^{-5} mm). The sodium is "torched" in a series of connecting glass containers and finally into a glass collecting chamber where it is stored until required.

The reactor coolant system mock-up is typical of the flow mock-ups produced by the glass shop. This assembly approximated the sodium coolant system employed in a power reactor. All circulating system components were reproduced in glass and included the heat exchangers, condensers, valves, by-passes, standpipes, and, of course, the pressure vessel.

Another assembly produced by the glass shop for engineering applications is the (Fig. 2) "sputterer," whose purpose is to "sputter" or *etch-off minute layers of the metallic cladding* that encase a radioactive specimen.

Some reactor fuel samples are encased in such a protective cladding when they are irradiated, in order to minimize contamination of the sample and of components surrounding the sample. In order to make a metallographic examination of the sample after exposure to irradiation, the cladding must be removed. Since the sample is extremely radioactive, it is not practical to attempt the removal by machining or any other method where operating personnel would be exposed to the radioactivity. The only possible way is through a controlled chemical action such as that permitted and controlled by the glass device.

This "sputterer" is an accumulation of ideas contributed by KAPL's metallurgical, engineering and shop-sections during two years of development work. Extremely close tolerances had to be specified in the fabrication of all components in order to permit complete parts interchangeability. Due to the intense radioactivity of the specimens processed in this apparatus, it also had to be designed for operation by remote control. Special tabs, handles and the general configuration have been designed to permit mechanical manipulators to grasp and operate the components easily.

Other types of glassware produced for engineering applications include: glass-insulated metallic thermocouple headers, multiple thermocouple glass leadout insulators, special welding and brazing envelopes, quartz annealing chambers, and furnace envelopes for annealing-firing various metallic elements and alloys at high temperatures.

The remaining half of the glass shop effort is devoted to the construction and maintenance of high-vacuum systems for the chemical laboratory and the vacuum systems operated in conjunction with mass spectrometer units. Glassware produced for these purposes includes mercury diffusion pumps of all types, mass spectrometer components, cold traps, condensers, and a variety of apparatus very familiar to most laboratory glass workers.

The routine maintenance of these high-vacuum systems is occasionally complicated by the presence of radioactive gases in the systems. When this occurs, the glass technician must take special precautions to avoid inhaling the gases. He does this by wearing a tank-type air pack, much like a skin diver, and a large face mask, and controlling the entrance of compressed air into the system through a hand valve. If no gases are present, the system is pressurized with a conventional oral blow-tube.

Mass spectrometers, among the largest and most complicated instruments at KAPL, are frequently large enough to fill a good-sized room. They are used to analyze small samples of radioactive materials for special characteristics. We have seven of these huge instruments at KAPL, which is widely recognized for the work it has done in the development and use of the mass spectrometer.

It is not surprising that our glass shop produces a large variety of mass spectrometer components for the Mass Spectrometry group including analyzer tubes, electron sources, electron multipliers and the vacuum systems used in conjunction with them (Figs. 1 and 5). The instrumented portions of these units are produced by the Special Products Shop, a sister organization. The Glass Shop produces the glassware with the required electrical lead-ins and fabricates all glass connections required for final assembly.

Tight seals are especially important, and in the course of producing this apparatus, almost every type of glass-to-metal seal is employed. Typical examples are the copper housekeeper seal, as well as kovar, tungsten, molybdenum, and platinum-to-glass seals.

The first seal, or housekeeper type, is especially interesting. It is produced by bonding the molten glass to a prepared copper sleeve which is feather edged to minimize the effects of expansion of the dissimilar materials. These seals have particular application in introducing heavy electrodes into vacuum tubes or chambers for electrical connections.

Platinum-, molybdenum- and tungsten-to-glass seals are usually produced in the form of a stem, as seen in the neck of a conventional light bulb, where the electrodes are introduced into the bulb. These seals have been used extensively in mass spectrometer assemblies where power is introduced to electronic devices enclosed in a vacuum system.

Of glass-to-metal seals produced by the Glass Shop, however, the kovar-to-glass seals are the most widely used. These are used in thermocouple headers, thermocouple insulators and in vacuum systems or other apparatus where it is necessary to make a transition from metal components to glass components.

Quartz-to-Pyrex, ceramic-to-glass, and a variety of other graded glass seals, are also produced as required for applications in the spectrometer.

Special molding techniques have been developed for the accurate and economical production of mass spectrometer analyzer tubes. Approximately five feet long, these tubes are bent to specified radii and flattened in

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the curved portion to approximately one third the original diameter. The mold developed for such work consisted of two graphite blocks approximately 48″ x 36″ x 2″, into which the mold relief was machined. Standard tubing was then shaped to approximately the correct radius, placed between the mold halves, and heated to temperature in an annealing oven. Compressed air introduced into the glass tubing forced the glass to conform to the shape of the contoured mold. Smaller molds of this type have been used to advantage in producing small lots of glass components where duplication is a prime requisite.

The fabrication of glassware for engineering applications has required the development of other new techniques and adaptations of glassworking techniques already known but seldom used in a conventional laboratory glass shop. For example, grinding techniques, utilizing optical lens grinder equipment, have been perfected in order to produce miniature thermocouple leadout insulators. Specifications required that the two insulator faces be exactly parallel and optically clear. The distance required between faces was:

$$0.020'' \pm \frac{.002}{.000}$$

Above one face of the insulator, a 0.015″ x 0.060″ shoulder was required whose surface also had to be parallel to the optical surface. These insulators were produced successfully utilizing the lens grinder and special holding fixtures.

In order to produce the many varieties of glassware required by the laboratory, the glass shop currently employs four glass technicians. These people were trained under a special program organized in 1948 for the purpose of producing qualified personnel capable of supporting the activities of KAPL components requiring glass fabricating services. Between one and two years of college work in the basic sciences was one of the desirable qualifications sought in applicants for the training program, so that they might better understand the application of some of the glassware required.

These technicians today are capable of producing glassware of the most complex designs.

The technicians receive only general direction from the foreman. Contact with technical personnel is encouraged and much of the work is assigned in such a manner that there is frequent direct contact between the glass technician and the technical requestor. In this way, the glass technician is able to make a maximum contribution to any development work to which he is assigned.

To encourage the relationship, only the initial contact by a Glass Shop "customer" is made with the foreman, who assigns a glass technician to the requestor. Thereafter, the requestor contacts the technician directly for any modifications or additional glass work associated with his particular development program. Operating in this manner eliminates the necessity of the foreman relaying information to the technician performing the work. Periodic discussion with the assigned technician provides an opportunity for the foreman to make suggestions and to maintain a record of job progress.

Most of the successful work requiring development of special glass apparatus is a result of this mode of operation.

As a result, too, the technicians have an opportunity to increase their technical knowledge, and the technical personnel can better appreciate the applications of glassware. Several glass technicians have co-authored and received credits in technical papers for work done under this system.

Furthermore, adapting glass to meet problems in the nuclear field has provided KAPL's Glass Shop with some challenging problems that frequently tax the skills and ingenuity of the most qualified glass technicians. It has been found that ingenuity plays as important a role in the production of special glassware as do the skills developed through years of experience. It is often necessary to deviate from conventional glass-blowing practices to produce some special piece of apparatus to the specifications established by engineering personnel. It is here that the ingenuity of the glass technician plays a major role in turning failure into success, and it is here that the benefits of the close contact between technician and engineer, physicist, or chemist really pays off.

Complications can arise with the advantages. Many engineering people are unfamiliar with the application possibilities—as well as the limitations—of glassware. As a result, some of their original requests for apparatus are impossible to fulfill and require tactful modification to a more practical design. Very few plans have to be rejected completely, however; the resulting equipment usually satisfies every one concerned, and it represents another step forward in the modern use of an ancient art.

RESEARCH DIGEST

(*Continued from page* 636)

their approval to XL-520 treatment.

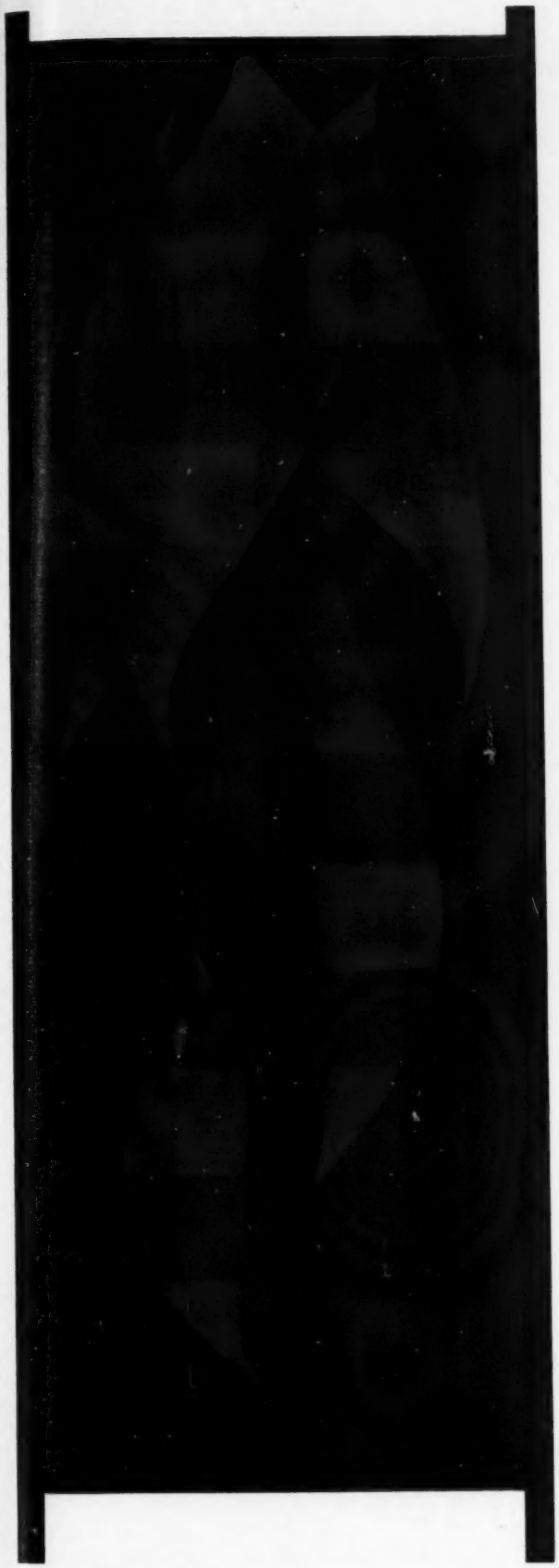
At the present time, a major bottler of soft drinks is evaluating the effectiveness of applying XL-520 each time the bottles pass through the filling line. Although these evaluations have not been completed and, as yet, no conclusions have been drawn the preliminary finds

TABLE III
SURFACE LUBRICITY OF CONTAINERS TREATED WITH XL-520

Application	Per Cent Silicone Solids	New	Slide Angle One Trip
Glass Plant	0.1	15°	42°
Bottling Plant	0.19	16°	28°
Bottling Plant	0.37	12°	34°
Bottling Plant	0.75	8°	35°

are of interest. To test the ease of applications XL-520 has been in use on one filling line in a bottling plant for over one year. After this period the spray equipment was found to be in good condition and in good adjustment. The storage tank had been cleaned once a month. This particular phase of this evaluation program has established that filling line application of XL-520 is feasible and trouble-free. It does not require the attention of a skilled technician. Other tests have established that XL-520 provides good surface lubricity

(*Continued on page* 660)



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The two types of Kaiser brick used are compositions developed specifically for the glass industry. They have exceptional ability to absorb and release heat, which greatly increases heat recovery and reduces fuel consumption. Their high density and absence of impurities provide the properties needed for superior resistance to batch carryover.

Kaiser Periclase "D" basic brick (95% MgO) are especially recommended for top courses in checker packings and for port arches and side walls. Installed in chemically bonded form, these brick become ceramically bonded with a tight network of pure Periclase crystals while the furnace is being raised to operating temperatures.

Kaiser Periclase "A" (87% MgO) brick are recommended for lower checker courses because of economy and durability under decreasing temperature and increasing load conditions. These ceramically bonded "A" brick have high resistance to carryover, maximum density, low porosity and high hot load strength.

For more supporting data on how the superior characteristics of Kaiser Periclase "A" and "D" brick can increase the service life of your checkers, write for our booklet, "A Report on a Better Basic Brick for the Glass Industry." And ask to see the 30-minute color movie, "Progress in Modern Basic Refractories." Arrangements will be made by your Kaiser Refractories Sales Representative or Regional Office.

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RESEARCH DIGEST

(*Continued from page* 658)

when applied to bottles on the filling line. Table III lists the results of several of these tests.

The slide angle was measured for treated bottles as treated and after one trip through a caustic washer. XL-520 exhibits good lubricity and some retention during caustic washing.

EFFECT OF HIGHER ANNEALING TEMPERATURES ON LEHR BELT ALLOYS

(*Continued from page* 601)

additions produce little or no increase in strength among the straight chromium steels; instead, the principal benefit is greater oxidation resistance. Depending on the amount of oxidation resistance required the user may choose among a number of steels, including 5 per cent, 12 per cent, and 17 per cent chromium steel. Although the 17 per cent chromium steel has adequate oxidation resistance for temperatures above 1400°F., it is not generally used above that point in a belt, due to lack of strength at higher temperatures.

In these temperature ranges special advantages may be gained by using austenitic stainless steels in place of straight chromium steels. At 1300°F., (See Fig. 1) in comparison with the creep strength of 5 per cent chromium steel, the creep strength of 18 per cent chromium-8 per cent nickel stainless steel is approximately 3 times greater, and the creep strength of 25 per cent chromium-20 per cent nickel is approximately 5 times greater. In terms of a lehr belt this difference in strength can mean one of two things:

1. It will permit the use of an open-mesh, lightweight belt with the same strength as a close-mesh, heavyweight belt of straight chromium steel. Having a more open mesh this belt would allow improved circulation in the lehr which would in turn allow more rapid heating and cooling within limitations imposed by the thermal capacity of the ware being processed. Having a lighter weight, the belt would require less time for heating and cooling and would help shorten the cycle while simultaneously decreasing heating costs.
2. The increase in strength brought about by an austenitic stainless steel can mean that such a belt will be considerably stronger than one of identical weave fabricated from a straight chromium steel.

There are several other important advantages. The superior properties of an austenitic stainless steel provide a built-in safety factor. If the belt should stop, or the operator should accidentally lose control of the temperature, or even if a short run at a slightly higher temperature is required deterioration or loss of this kind of belt may be prevented.

Austenitic stainless steel displays a greatly improved resistance to scaling and consequent resistance to marking of ware, as compared to a straight chromium steel. For example, a sample of a stainless steel (25 per cent chromium-12 per cent nickel) lehr belt was recently examined after 7 years' operation at 1200°F. It was found that oxidation had caused the loss of less than five-ten thousandths of an inch of metal from the wire diameter.

As temperatures in lehrs increase, a great many factors must be taken into consideration in specifying alloys for belt fabrication. Besides the necessity of proper construction for the temperature and load involved, the material must possess both the chemical and mechanical properties required to withstand the destructive effects of high-temperature operation. It must permit the production of a sound, strong and ductile weld; resist embrittlement over long periods of operation at high temperatures, or over periods of alternate heating and cooling; resist progressive oxidation tending either to scale its surface or penetrate intergranularly into its interior.

Up to certain temperatures, varying with the metal or alloy in an oxidizing atmosphere, the metal or alloy may be protected by the formation of a thin, adherent oxide film. Above the scaling temperature, the metal or alloy forms a scale after prolonged heating. In some cases, this scale will be of sufficient thickness to cause flaking or spalling. Further, when special processing of the ware while still on the belt is involved, the type and effect of such processing on the belt itself must be given full consideration.

With these considerations in mind, here are some of the alloys that could be used in the increased temperature ranges.

1400°F. - 1700°F.

Beginning at 1400°F., an austenitic stainless steel becomes a necessity. These alloys, on exposure to oxidizing atmospheres develop a protective oxide surface which is tightly adherent and has a coefficient of expansion similar to that of the base metal. There is little tendency for the belt to throw off the oxide coating as it alternately cools and is reheated.

The alloy 25 per cent chromium-12 per cent nickel is widely used in this range and has good load-carrying and oxidation-resistant characteristics.

Even more widely used, however, is 25 per cent chromium-20 per cent nickel stainless steel. With a higher nickel content than 25-12, it displays considerably improved creep strength and oxidation resistance. This alloy is considered well balanced in its constituents, and it has excellent resistance to spalling of the scale under conditions of thermal cycling. In industries closely allied to the glass manufacturing it has found wide acceptance for operations such as porcelain enameling at 1600°F., firing of coatings on ceramic capacitors at 1400°F., firing of table ware at 1700°F., pottery decorating at 1500°F., and firing of under glaze on pottery at 1700°F.

Another alloy finding increased usage in this temperature range is 35 per cent nickel-19 per cent chromium. This alloy also provides excellent creep strength and oxidation resistance and is particularly suitable for applications involving severe thermal shock. It is being used for firing of multiform objects at 1600°F. in addition to many of the uses listed for 25-20.

Up to 2100°F.

While the 25-20 and 35-19 alloys are regularly used up to 2100°F., there are others which should also be considered, such as Inconel which contains 78 per cent nickel and 15 per cent chromium. This alloy offers versatile engineering properties. It possesses freedom

from weld decay resulting from carbide precipitation at elevated temperatures and is also one of the group of nickel-chromium alloys that combines highest resistance to oxidation with highest strength at elevated temperatures.

Another alloy very widely used is 80 per cent nickel and 20 per cent chromium which combines excellent oxidation resistance with high strength and possesses excellent structural stability. In addition to its wide usage up to 2100°F. by the metalworking industry it is used in gloss kilns up to 2050°F.

An alloy which has only recently become available is one which contains 74 per cent nickel, 20 per cent chromium and 4 per cent aluminum. This shows excellent possibilities in applications where product contamination is a problem and where temperatures may range slightly above 2100°F.

All of these alloys are being used today for fabricating metal-mesh belts, and although they offer other advantages in addition to heat resistance, this important characteristic will undoubtedly make them interesting to lehr builders and operators.

ERRATUM

Niels von Bülow, Deutsche Glastechnische Gesellschaft, has been elected vice president of the International Commission of Glass, rather than president-elect, as reported in the August, 1959, issue, page 428.

Mr. von Bülow was elected at the final session of the Commission's annual meeting in Munich, Germany, in July.

The election of a new president-elect will take place at the annual meeting in 1961.

GLASS CONTAINERS

(*Continued from page* 611)

it will yield improved appearance and "feel," and will reduce the costs of protective packing materials. In addition, silicone coatings will impart water repellency and release properties. This latter property has found widespread use in pharmaceutical vials for clean drainage of antibiotic solutions; it is now being examined with interest by food packers.

Like all new products, many difficulties of application have been encountered. Because of their extreme dilution, the silicone solutions require specialized spraying equipment. Their future will be watched with interest.

Glass Containers and Oil Wells

A novel adaptation of glass containers has been made in the process of shooting an oil well. Borosilicate glass containers commonly called "jets," protect accurately shaped explosive charges from liquid pressures of several thousand pounds per square inch in wells as deep as 3 or 4 miles. When the explosive charge is detonated, the glass container disintegrates completely, leaving no residue to interfere with the oil pumps or gauges of the oil-handling equipment.

The shaped explosive charge usually forces a neat hole through the well casing without leaving any burrs or rough projections on the side of the casing. The perforations permit oil from the rock formation to enter the steel well casing and be brought to the surface. The development of these containers, plus the continued improvement in perforating techniques, has been instrumental in greatly increasing the world's known oil reserves.

The development of the glass container for shaped charges is more evidence that glass is becoming an engineering material capable of doing an unusual job for science and industry.

RAW MATERIALS

(*Continued from page* 627)

lepidolite in borosilicate glasses. However, it may very well be the preferred mineral for television glasses. It is also believed that lithia may aid the container glass industry by increasing melting rates. There are a number of projects under way to investigate this use.

The continued supply and use of lithium minerals and chemicals will depend to a great extent on whether or not the government continues its program of stock-piling these strategic materials.

Cerium

Cerium in flint glass has market potential in the container field due to its ultraviolet absorbing properties. Containers made of such ultraviolet-absorbing glass should be considered for use in packaging materials which tend to be spoiled by light. Such materials are now often packed in amber glass bottles. The list of products now using amber glass is long and varied. Vegetable oil products, beer bleaching solutions, and pharmaceuticals are a few of these items.

The fact that cerium glass can be colorless in visible light and affords the advantages of protection from ultraviolet light is the most important feature. Pharmaceutical pills and capsules, for instance, are produced in many bright colors; psychologically they are more attractive to the eye and supposedly more palatable, but are marketed in most cases in a drab, brown bottle. A major brewery packages its beer in clear flint bottles which show the purity of their product, but it does not receive the advantage of ultraviolet protection.

The color of the cerium glass will vary from colorless to straw or brown if selenium is present. Manganese decolorizing shows promise when used with rare earths. With the use of cerium, it may be possible to use higher than normal iron-bearing sands in the glass batch.

Nearly colorless glasses showing ultraviolet absorption may also be made with cerium oxide in combinations with cobalt or vanadium oxides. Vanadium tends to impart a green yellow color to the glass, but cobalt and cerium oxides produce glasses which are nearly colorless or have a very light blue color. Suitable ultraviolet-absorbing glasses contain 1.9-6.5 per cent CeO_2 with 0.5-2 per cent V_2O_5, and 2-3 per cent CeO_2 with 0.01-0.02 per cent Co_2O_3. With cerium content as low as a few tenths of a per cent, the ultraviolet absorption may still be enough to make useful containers.

Cerium hydrate is the usual form of adding cerium

to the glass batch; however, for low-cost application, the cerium should be added in its cheapest form.

Rare earth sodium sulfate presents the most economical source of 21 per cent CeO_2 for use as the glass additive. The use of rare earth sodium sulfate as the source of cerium has been verified by actual batch tests.

The composition of rare earth sodium sulfate is $RE_2(SO_4)_3.Na_2SO_4.2H_2O$. It is a light pink crystalline powder, sparingly soluble in water and acids. In normal manufacture it is dried and some of the water of hydration (combined water) is removed. The pink color is due to the rare earth neodymium.

Rare earth sodium sulfate is a primary product obtained from the chemical processing of cerium ores such as monazite. Therefore, it is the cheapest source of cerium where the other rare earths do not interfere in its use. For ultraviolet absorbing glass use, these other rare earths do not interfere and may actually serve a useful purpose as physical decolorizers.

FLAT GLASS

(*Continued from page* 617)

wall construction, they offer a means for economically maintaining comfort and health throughout the year. Double insulating glass for windows has solved many problems for architects, builders and homeowners and is gradually making single glazing windows obsolete in a broad range of climates.

The window consists of 2 layers of ⅛-inch thick glass separated by a 3/16-inch air space.

The air between the 2 panes of glass is removed in the manufacturing process and replaced with specially dried air. Internal air pressures are adjusted to enable the insulating units to withstand atmospheric pressure in all parts of the United States having altitudes under 3,000 feet.

This new insulating glass is as simple to install as a single thickness of glass; it is available in sizes up to 50 x 62 inches.

Indoor Sky

Three lighting principles are incorporated in the fundamental design of the several types of lighting ware:

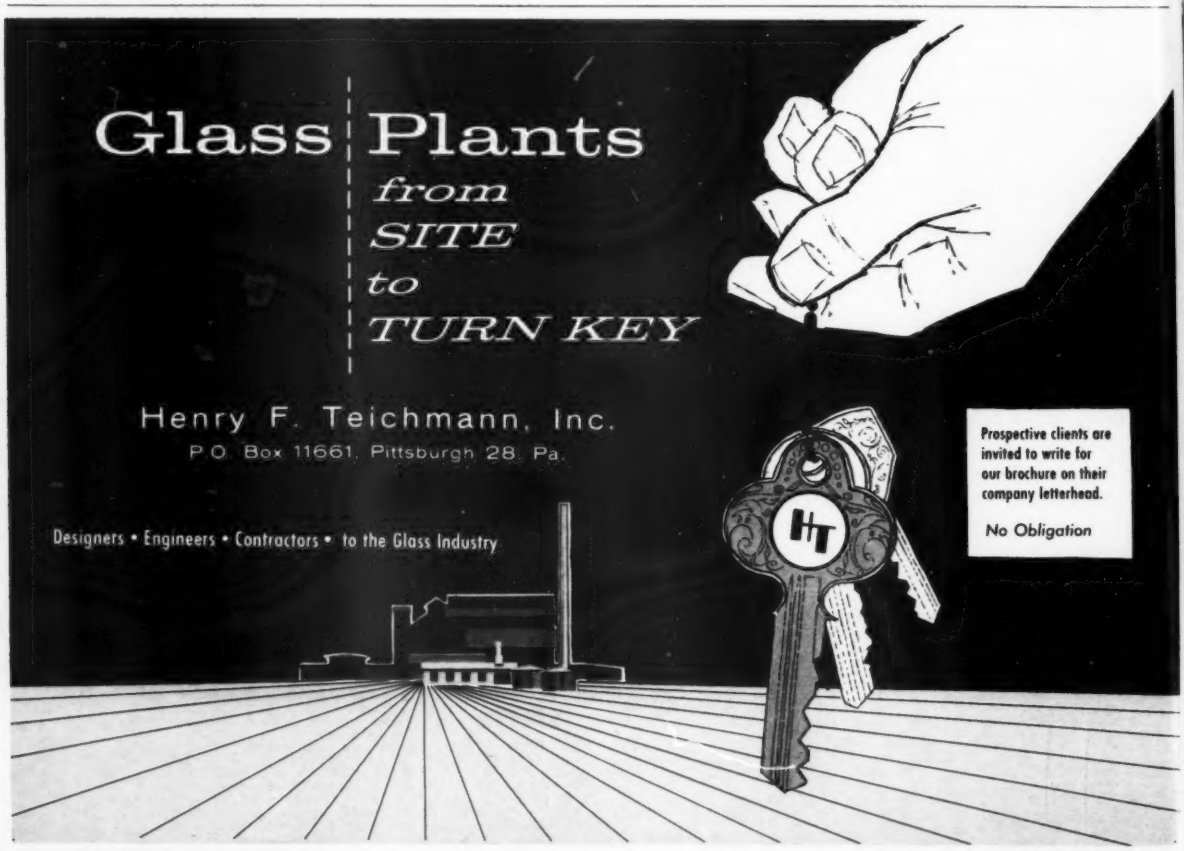
1. Prismatic.
2. Diffusing.
3. Louvering.

To meet these varying requirements, Corning scientists have developed glasses of different characteristics: water-white crystal, for prismatic panels, to give maximum light transmission and color control; opal glass, for soft diffusion, photosensitive glass, for louvering effect; and borosilicate glass for resistance to incandescent lamp heat.

For installations requiring relatively high intensity, free of glare, prismatic designed glassware is widely used.

Where light diffusion is desired, panels of opal glass give complete diffusion and excellent brightness control.

Louvering action, without unsightly egg-crate grids, is



possible with photosensitive glass. Through a photographic process, whereby an image is produced in the glass itself, opal louvres are separated by crystal-clear cells. Vertical light passes unrestricted through the glass while high-angle glare is cut off by the louvres. The Fresnel-type prismatic lenses are produced in a wide variety of sizes, shapes and optical characteristics which give complete flexibility of design.

Each of these forms of lighting ware can be adapted to different requirements. In some instances the lighting actually becomes part of the interior theme and luminaires take such shapes as wide bands, squares, or circles of light. Fluorescent troffer lighting is also popular because it can be recessed or surface mounted and can be arranged individually or in continuous rows.

The Glass Automobile

The designer's dream of the futuristic glass automobile is now technically feasible and is soon to become a reality. Improved laminated, heat-tempered, electrically conducting glasses, and a better technique of bending and forming sheets, make further use of glass for automobiles practical. It is now possible to put a glass band around a car and provide a glass roof; in fact, it is possible to enclose the car in glass, except for supporting members. Newer applications of glass in automotive construction are expanding to the point where finding enough space to support the top and keep it rigid is the main problem.

In recent years, the automotive replacement trade has expanded not only in unit volume, but also more significantly in the total footage of glass. Since 1945 the average automobile windshield and backlight have increased over 70 per cent in size, and entirely new shapes have been developed. Where the jobber or dealer formerly sold two pieces of flat safety glass for about $7.00 in 1946, today he can sell one beautifully curved, wrap-around windshield for as much as $50.00.

Improved Reflecting Mirror

A three-way rear-view mirror for automobiles has a shift device which provides for normal day driving, reflecting about 60 per cent of the light mostly in the comfortable green and yellow range; beam splitter layers used for night driving reduce light intensity to about 11 per cent of normal and are in the red range to emphasize signal colors. Under high-glare conditions the mirror may be shifted to a third position. The glass is given a slight wedge, and metal-oxide coatings are used on both sides. Light beams are split so as to reflect some colors toward the driver, bounce others out of sight, and let some pass through to the back surface.

Packaging of Curved Windshields

Larger windshields and their intricately curved design require greatly increased storage and handling space, as compared with the small, flat windshields or block-sized laminated glass of a few years ago. Cartonizing equipment has been put into the new warehouse so that jobbers may be served with the conventional production packs of 20, 25, or 30 windshields, smaller packs of eight

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windshields or individual windshield parts cartons. Block sizes of flat safety plate and safety sheet glass will also be cartonized in packs of six lights each for shipment to jobbers. The warehouse is 1,100 feet south of the two large plate glass melting furnaces at East Toledo so that it relieves the bending, laminating and packaging facilities in the production area from interference or congestion.

Experimental "Dream" Cars

General Motors, which first introduced the "Dream" car idea to the auto industry 17 years ago, presented at the 1955 Motorama 7 new experimental cars and one truck, embodying advanced concepts in design and engineering and many new uses of glass in sheet and fiber forms.

Heat-Resistant Glass

Glass which shuts out intense heat has been developed by permanently bonding a thin, transparent film to the outer side of glass panels. It will turn back about 60 per cent of the hot infrared rays from fiery steel; yet, the panels are transparent so the operator can see and control the bar as it moves through the shear.

It has further been proposed as a transparent shield for banks of powerful spotlights and may provide an answer to the "hot light" problem in television. It may also have a use as a windshield for vehicles in steel furnace rooms, or as a transparent floor for cabs of overhead cranes handling hot ingots or molten metal.

Improved Laminated Glass

A new glare- and heat-reducing glass with a slight bluish-green tint, has been produced as a safety plate for windshields, both flat and curved, and side lights in motor cars. Batch formulas have been modified, so that the glass will eliminate a large percentage of glare and heat, but transmit sufficient light to meet vision requirements in motor cars by shutting out a large percentage of ultra-violet rays. The glass reduces glare from the sun and on-coming headlights, and it keeps the interior cooler. Sunlight, weather, and passage of time have practically no effect on the color.

These glasses are being used in buses as well as insulated windows in air-conditioned railroad passenger cars.

By employing metal molds, carefully controlled heat and continuous moving conveyors, modern bending methods have become a production line operation.

For laminated curved glass, the twin lights of glass are put through the process together so that they will have identical curvature. The primary concern in bending glass is not simply getting the proper curvature to fit the automotive stylist's conception, but the optics of the finished product.

Actually, it required about 10 years of development work to achieve the panoramic windshield, without sacrificing clearness or strength. This was accomplished in 1954, one of the great years of advancement in automotive design.

Another innovation is the shaded windshield which has a band of greenish-color impregnated in the plastic

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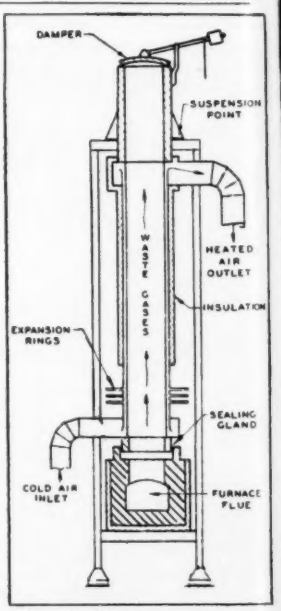

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TOLEDO ENGINEERING Company

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interlayer. It is delicately shaded in density, ranging from a maximum at the top to a scarcely distinguishable shade a few inches below, but still above eye level. This windshield replaces exterior visors, interior shades, or sunglasses in bright sunlight and provides generally comfortable driving. Even though infra-red and ultraviolet rays are excluded to a considerable extent, more than 70 per cent of the visible light is admitted. There is still good visibility through the shaded upper portion of the windshield.

Glass in Aviation

In the field of aviation, successful supersonic flight will depend upon the ability of the wing and fuselage surfaces to resist high temperatures. It has been estimated that these temperatures may reach 500-1000° F. at the higher supersonic speeds of 2600 miles per hour. Glass fabric laminated with phenolic resins or silicones, according to aeronautical engineers, can maintain a high percentage of its strength at approximately 500° F. Another advantage is the lower coefficient of expansion of the laminated material as compared to metal alloys. The quality means less dimensional change and a reduction of structural warpage that could cause serious control problems.

Window For Supersonic Wind Tunnel

This piece of optical glass, weighing 1600 lbs., is one of two of the largest pieces of optical glass over made. They will be used in the 6 x 6 supersonic wind tunnel of the Ames Aeronautical Laboratory of the National Advisory Committee for Aeronautics at Moffett Field, California. This tunnel generates wind velocities up to twice the speed of sound, equivalent to 1500 miles per hour at sea level.

The windows are 6 inches thick and 52 inches in diameter. They are so clear and free of imperfections that photographs of shock-wave and air-flow patterns can be made through them to furnish scientific data of great value in the design of future airplanes and missiles for supersonic flight.

Until research and glass-making skill found a way to mass-produce pure optical glass in large shapes, science had no suitable material for wind-tunnel windows. Perfect optical glass with enough area to permit a full-view and thick enough to withstand the enormous wind-tunnel forces has been the answer.

Windows for Jet Planes

Aircraft glass has to be handled with extreme skill as it passes through bending furnaces and heat-treating; assembly of glass, plastic and metal edge sandwiches; and lamination. It must be checked with precision instruments at every turn to meet the final rigid military specifications.

While the average automobile laminated safety glass is about one-quarter-inch thick, many of the aircraft windows are two or more inches thick with many layers of glass laminated into a high-quality optical instrument. Certain of these glass layers are heat-treated to make them five or six times stronger, tougher and more flexible than the conventional plate glass.

Where aircraft in the last war flew 300 to 400 miles per hour, now they often dash through the air at supersonic speeds of 1200 miles per hour, or faster. Slight

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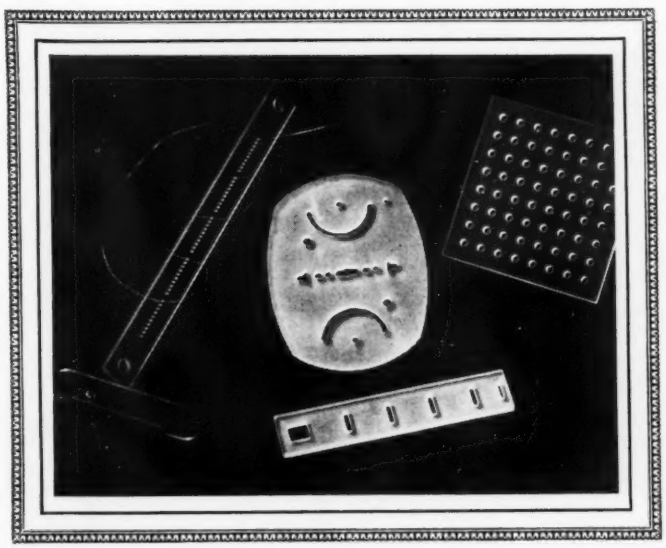
- ☐ 1. Molded flint glass
- ☐ 2. Water glass
- ☐ 3. Fotoform glass
- ☐ 4. Thermoplastic acrylic resin

If you picked No. 3, you're on the beam. All of these objects are made of Fotoform glass, a material which can be formed into a variety of extremely small components. Shown are: a stylus guide threaded by a human hair, a vacuum tube spacer, an electrical relay pusher bar, and a 64-hole perforated plate. Through nearly 70 years of supplying Soda Ash to the glass industry, Wyandotte has seen science teach glass to do many new tricks. Today, as in the past, Wyandotte is a working partner supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.



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distortion in windows could mean disaster. Much of the aircraft glass must provide maximum visibility in all kinds of weather; hence, the built-in electrical conducting glass with transparent coating which provides resistance heating to melt away ice and fog.

The greater speeds and higher altitudes require aircraft glass of maximum strength. Aircraft glass embodies almost every manufacturing process so that it is a recapitulation of the most modern techniques used. Some units even employ the double-glazed insulation idea. In aircraft glazing, metal edges are laminated into the glass which is curved to fit the plane contours.

New Colored Glass

New and attractive colors are being added to flat glass making possible a wide variety of color combinations. Transparent mirrors are available in 30- to 60-in. sizes of polished plate, 13/64 in. thick, instead of the former 30- to 40-in. size.

Light gold plate glass excludes more than 99 per cent of the sun's ultraviolet rays. Used widely in the South and West, this glass lends a distinctive appearance to stores, reduces fading much more efficiently than the regular polished plate glass.

It is not measurably affected by time, light or weather exposure, and it has a visible transmission of average daylight of about 80.7 per cent.

The usual color of the materials protected by the gold plate glass is changed somewhat, but the effect as a rule provides a richer color. Color corrections are necessary and are usually provided by certain types of lighting.

Two additional colors, shell pink and gunmetal, have been developed for structural glass and are presently available in 11/32" thickness only.

The shell pink glass, which requires a considerable quantity of gold in its manufacture, is priced somewhat higher than standard colors. Designed both for special store fronts and for fine homes, it combines effectively with white for lower-cost installation.

The gunmetal color was developed primarily to fill the need for a very dark, rich color to enhance show windows and is especially effective for framing and accenting show areas. Combined with other colors it offers unlimited effects for interior decoration.

Improved Electrically Conducting Glass

Another solution to exterior windshield icing and interior foggings in aircraft is being achieved through the use of a transparent, durable, electrically conductive coating on glass.

When applied to a glass panel, its unique properties make it possible to heat the entire area of the panel by the uniform flow of electrical energy across one of the glass surfaces without distorting visibility through the panel and with no serious reduction in the intensity of luminous transmission. At present the reflection of a glass surface treated with this coating is somewhat greater than that of untreated glass.

Also, the surface produced by the present coating method presents an iridescent appearance in reflected light because of the selective reflection of different wave lengths of light and the interference effect resulting from slight variations in thickness. However, both the intensity and the color variation of reflected light are minimized by laminating the coated surface to another plate of glass with an intermediate bonding layer of plastic. The unaided eye can detect no color differential in transmitted light, and visual characteristics are approximately the same as untreated glass when various laminates are used.

One of the secondary, but vitally important, characteristics of this treated glass is that the coating actually strengthens the glass against impact at low atmospheric temperatures, making it more resistant to fracture than other types of glazing.

Electrical contact to such glass is made by painting on bus bars a silver plate which, when properly fired, becomes metallic silver. Copper wires, or other suitable connectors can be soldered to the silver. The treated glass unit de-ices and de-fogs because its electrical resistance is relatively low, affording a means of converting electrical energy into heat energy over the entire expanse of the transparent windshield area.

The chief problems in developing a specially coated glass whose surface would dissipate static electricity were:

1. Maintaining maximum visibility.
2. Producing a surface sufficiently durable to withstand ordinary usage.
3. Providing means of discharging the built-up electricity.

A slight amount of haze is sometimes present, but the panel transparency is only slightly less than a freshly cleaned glass. It is reasonable to assume, however, that it will be possible to produce similar glass with moderate curvatures, both simple and compound.

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Electrically conducting coatings have also been used in the glazing of railroad signal towers at important locations where ice and sleet storms are frequent in winter months. Other suggestions include the use of such coatings in non-fogging mirrors for bathrooms.

Glass for Atomic Power

The development of atomic power has necessitated the use of a transparent barrier for gamma rays. For this purpose cerium-stabilized lead glass windows have been produced which are 4 inches thick, about 3 x 4 feet in area, and weigh approximately 1,000 pounds. These windows are the heaviest in the world and will be framed in steel for assembly in the final atomic "cave" walls. Some windows will be 12 or more sections deep and will absorb the gamma rays without turning brown, maintaining their original transparency.

Radiation-Resisting Glass

Completely assembled radiation-shielding windows for nuclear research are now on the market. Consisting of castings of radiation-resisting glass up to 10 inches thick stacked together in a framework, the units are shipped ready to install in test cell walls.

The windows, whose purpose is to protect research personnel by reducing radiation intensity to a tolerable level, permit visual observation of work carried out remotely in "hot" areas. The new package units, available as either wet- or dry-type assemblies, eliminate construction and assembly work at the laboratory site. Wet-type assembly windows are shipped already charged with index oil.

Special glasses with densities of 2.7, 3.3, and 6.2, are used in the "package" windows. These closely match the radiation-absorbing properties of ordinary concrete, barite concrete, and iron or steel. Each of the glasses is sufficiently stabilized for all practical purposes to prevent the darkening effect of X-ray or gamma-ray exposure.

Detection of Atomic Radiation

A locket-size glass dosimeter records the radiation to which it is exposed. It weighs less than an ounce and is small enough to fit in a watch pocket.

More than a million of these atomic radiation detectors have been produced for distribution to the United States Navy and Air Force Personnel.

The dosimeter is noteworthy for its range, as it can measure doses from 10 Roentgens (below the danger limit) up to several thousand Roentgens. It survives shock, immersion and temperature tests, and has an indefinite life.

The heart of the dosimeter is a piece of silver-activated phosphate glass enclosed in a locket. This permanently records the radiation received, making it possible to measure the amount of exposure immediately, or weeks later, by means of an auxiliary instrument, known as a fluorophometer, or "reader."

When illuminated by ultraviolet light in the reader, the phosphate glass emits fluorescent orange light in amounts proportional to the radiation absorbed. The reader indicates the amount of this radiation by measuring the intensity of the orange light emitted. The reader, which can measure approximately 150 dosimeters per hour, does not require trained personnel to operate it.

GLASS BLOCKS

The use of glass blocks, window glass, plate glass, and other forms of fenestration has assumed widespread fundamental importance. One large glass company has established a Daylight Research Center dedicated to the development of planned daylighting.

Daylighting Nomograph

As a result of careful analysis of daylighting surveys conducted in schools throughout the country scientists have begun to realize that a definite relationship exists between illumination and such factors as fenestration design, geographical location, and time of year. Many surveys have shown this relationship to be quite consistent.

A detailed examination of the data indicated to the researchers that daylight illumination could be predicted. This discovery led to a Daylighting Nomograph, which permits the accurate prediction of daylight and brightness levels in any section of a room for any time of day. The only information needed to operate the nomograph is that which is available from the architect's plans and the local weather bureau.

Fenestration design can be checked for efficiency before construction begins. Some recommendations of the research center are:

a. Lower Classroom Ceilings. The high ceiling was based on the need for high fenestration areas so that the daylight could penetrate to the far side of the classroom. This reasoning no longer applies when light-directing glass blocks are used. It is the blocks in the lower half of the panel which provide the greater part of the light in the recesses of the room. While the over-all illumination level may be lowered slightly, the quality and quantity of illumination will continue to be good if the ceiling height is reduced. The lower ceiling substantially reduces construction costs.

b. Glass Block Design. A number of functional glass blocks have been designed in 8″ and 12″ shapes. The prismatic design of each block has been specifically developed to control daylight effectively under any given set of exterior lighting conditions. Because these conditions vary on the elevations of a building, and in many regions of the country, it is necessary to have a light control medium designed to do a specific job. A single, all-around light control device is a poor compromise because it must either transmit so much light in sun exposures to be comfortably bright or so little that inadequate light is delivered.

Glass Block for Toplighting

A moderately important factor last year was the use of specially designed blocks for toplighting.

A new series of glass blocks that reduce glare and solar heat again have been designed to control high brightness problems resulting from sun and snow. They contain a pale green fibrous glass diffusing screen that reduces surface brightness or glare by 35 per cent, and bring about a heat gain of 25 per cent.

These blocks are available in three different 12-inch

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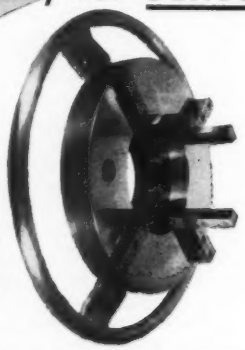

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functional patterns, including a special toplighting block for use in skylights. They are also available in a light-directing pattern which throws light to the ceiling; a light-diffusing pattern that scatters the light in all directions; and toplighting glass blocks that distribute light over wide floor areas.

The exterior face of this block has almost twice the impact resistance of standard blocks; in other respects —such as over-all thickness, insulation value and weather resistance—they are the same as other double-cavity blocks.

At normal room humidities, it is almost impossible to make condensation form on the bottom of such a panel. When these panels are compared with ordinary skylights, the difference is marked. Assume a typical room with relative humidity of 38 per cent and interior temperature of 70° F. With an ordinary skylight, condensation will form at 39° F., but with the improved blocks, condensation will not form until the outside temperature has dropped to 29° F. below zero.

The top surface of the block is smooth; normal rainfall keeps it clean. Inside each block, there is a partial vacuum which is divided by the fibrous glass-diffusing screen into two dead air spaces. This screen reduces heat loss and gain and also helps diffuse the daylight. Both inner surfaces are stippled. The edge of each block contains an opal glass insert which reduces edge brightness and makes the panel easy to look at from any angle.

Glass blocks have long been under consideration as a toplighting material, but until now there has never been a satisfactory installation method. Some builders formerly tried supporting ordinary glass blocks in a lattice of wood or metal, using various sealers and adhesives, but the adhesives deteriorated, sometimes softening and staining the surroundings.

The standard line of functional glass blocks is a careful balance between maximum usable illumination and low panel brightness—under average exterior daylighting conditions. This method of fenestration is very simple and effective and probably no other method of glazing will give such high illumination along with such a low brightness level. For most purposes of outside lighting, where average conditions exist, the functional glass block is ideally suited.

For use where outside glare may be quite severe a modified glass block has been employed.

These blocks are available in three different patterns:

1. Light directing prism for use above eye-level,
2. Light diffusion prism only, and
3. Light-direction prisms for use in top-lighting systems. The controlled-lighting blocks have about 35% less brightness and 25% less instantaneous heat gain than standard glass block.

The insulating efficiency is equal to that of an 8-inch masonry wall, or about twice the insulating efficiency of ordinary windows. This type of block is now available in both 8-inch and 12-inch sizes.

Engineers have long felt that glass blocks possessed an unusual number of advantages as a wall material rather than just a means of filling a window space.

The addition of color to glass blocks, together with the curtain wall technique, gives the architect freedom of design not only in adding color where he chooses on the exterior of the building, but allows the double use

of the color in presenting a glowing wall of color on the exterior and interior both by day and night.

With the introduction of new colors (blue, green, yellow and coral) and the added emphasis on glass block curtain walls, there is every indication that new applications for the versatile glass block will continue to appear, along with a rising market.

New Skylight Glass Block

This new light-diffusing glass block is specially designed for use in skylights, both structurally and optically. The insulating value has been increased ($U = 0.43$) by the addition of a fibrous glass screen sealed in the block which creates a double cavity and provides better daylighting control by diffusing the light.

AND NEW PRODUCTS

(*Continued from page 625*)

New Lighting Techniques

New adaptation of photosensitive glass has produced an improved form of louvre panel that gives promise of improving illumination considerably. The louvres, in the form of opalescent planes, are ingrained throughout the width, length, and depth of a $\frac{1}{8}$ inch thick pane of glass, providing a more permanent and acceptable type of shield for lighting fixtures. This also permits shallower lighting fixtures than possible with other types of louvre lighting. Color changes in light, which often occur when metal and plastic louvres are utilized, are completely eliminated.

Pyroceram

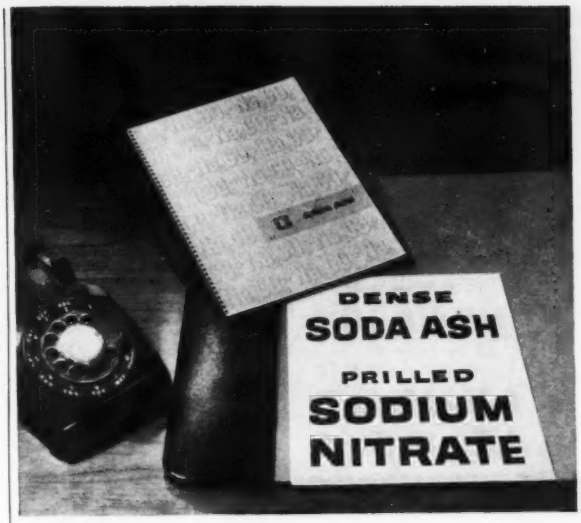
A family of new materials developed by Corning Glass Works in 1957. The basic materials are harder than high-carbon steel, lighter than aluminum, and, according to the company, up to nine times stronger than plate glass.

Pyroceram is made by adding special ingredients to the raw materials of a glass batch. After the glass has been cooled to solid form it is passed through a heat-treating process which transforms it into an extremely hard, fine-grained substance. Each batch contains one or more nucleating agents which, upon subsequent heat treatments form billions of submicroscopic crystallites. As the heat treatment continues, each crystallite acts as a center of crystal growth. By controlling the chemical composition and growth of these crystals it is possible to obtain a variety of properties.

The end product, after heat treatment, is an extremely fine-grained crystalline material, nonporous, impermeable, and harder than most ceramics and many metals. It is adaptable to mass production and can be pressed, drawn, blown, rolled, and centrifugally cast.

Ultrasonic Delay Lines

Fused silica is being used for the construction of solid ultrasonic delay lines which have a delay of 3,333 microseconds. Among their outstanding properties are the lack of cavitation under shock conditions, operational stability over a wide temperature range, and wide band width.



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The characteristics of the material indicate that the fused silica lines will make important contributions in improving radar detection of moving targets.

The fused silica is made by a chemical process from non-crystalline materials of controlled purity and transmits an ultrasonic signal almost 100,000 times slower than electrical signal in wire. It is similar to fused quartz but is purer, and possesses a more homogeneous structure.

Disk-like in appearance, each line consists of a thin polygon sheet of fused silica. The sheets are cut and ground by precision methods similar to those used in the preparation of optical glass to meet tolerances up to ±0.0003 inch. After testing, the glasses are mounted and cushioned inside an aluminum casing.

Cooking with Light

A new lamp, unique in construction, may be the heating element of tomorrow's electric range. The bulb itself, made of 86 per cent silica glass, is rugged enough to withstand the sudden shock of the heat generated by the lamp's 1500 watts.

High-Temperature Ceramics

Manufactured for high-temperature uses where material expansion is critical, Corning's lithium-aluminum silicate low-expansion ceramics are formed in a variety of shapes by slip casting, hydraulic pressing, and extrusion.

One particular ceramic has a zero coefficient of expansion and can be used continually at temperatures up to 1830° F; short-term temperature peaks can go up to 2100° F. With a flexual strength of 8000 psi, it is gas tight and has a specific gravity of 2.3.

The materials are particularly resistant to molten aluminum and are being investigated for use as furnace linings for aluminum melting tanks and for molten, aluminum containers. Other potential uses include kiln furniture, crucibles, firing supports industrial and laboratory furnaces, and calcining trays.

Practical Use of Radioactive Materials

A technique has been developed and applied, on a laboratory scale, for using radioactive sodium in determining the efficiency of dealkalization of the glass surface as a function of time and temperature.

This technique is one of the first applications of radiochemistry and nuclear physics to the solution of a practical glass problem. Properties such as the chemical durability, surface electrical conductivity, and the strength of glass are functions of the concentration of alkali on the surface. The improvement of glass, with respect to these properties, often depends on how effectively the alkali has been removed from the surface layer.

Glass Solder

Some progress has been made in the development of a useful technique for sealing glasses together by means of suitable soft glass enamel which acts as a solder and can be accomplished without deformation of the glass parts themselves. This method is in marked contrast to the normal procedure of sealing by fusion. Glasses

particularly applicable are the lead-borate type covering the range 50-90 per cent PbO. The remainder is boric oxide. In order to improve the durability of these glasses, other metallic ions were introduced, mainly barium and zinc, as well as small percentages of silica.

Artificial Gem Stones

A glass made from lead, titanium, and boron oxide is being used for optical work and artifical gem stones. It has a high index of refraction (greater than 2.0) and possesses good dielectric strength.

Feeders For Optical Glass

Improved glass feeders have been developed that are said to deliver glass free from cords and other defects, so that the glass may be used for optical purposes. The feeder is provided with 2 orifices, one of which draws off cordy and otherwise defective glass and discards it. At the same time, the glass of optical quality goes through the other orifice, which acts as a feeder to presses or other forming devices.

Glass Opaque to Ultraviolet

Glasses which are transparent to visible radiation, opaque to ultraviolet, and are colorless, or nearly so, contain cerium and vanadium, or combinations of the two. Cerium and cobalt are also used successfully. Such glasses have application to the protection of historical documents, tapestries, wearing apparel, book bindings, and similar materials.

Coating Mirrors

Patents have been issued covering a method of applying a coating of quartz to glass, mirrors, or other substances, where the coating reduces reflection and provides a hard covering which resists scratching. A vacuum technique is employed to evaporate silicon monoxide or quartz in the presence of a solid silicon reducing agent and deposit a layer on the mirror or other article to be coated.

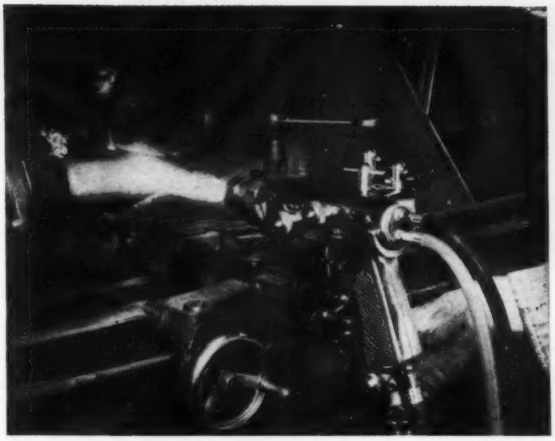
Camera Windows

An application of fused silica is found in camera windows, maintaining high optical qualities under extreme temperatures experienced in wind tunnel operations and ultrasonic missile work. The windows have a low index of refraction variation (on the order of 2×10^{-6} per inch) and can withstand temperatures up to 990° C.

These fused silica windows can be used to protect cameras and other delicate recording instruments from skin temperatures of high-speed aircraft or guided missiles. They are extremely resistant to thermal shock, having a thermal expansion coefficient of 5.6×10^{-7} per degree C.

Components of Heat-Resistant Glass

Two special components of heat-resistant glass are key units of the all-glass oven featured in the General Motors (Frigidaire Division) "Kitchen of Tomorrow," exhibited at the 1956 Motorama. A transparent dome of borosilicate glass covers the counter-top oven, and a disk of Vycor brand glass forms the unit burner plate which can



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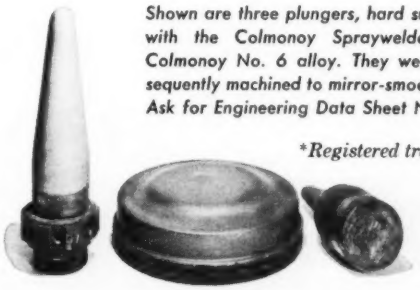

Shown are three plungers, hard surfaced with the Colmonoy Spraywelder and Colmonoy No. 6 alloy. They were subsequently machined to mirror-smoothness. Ask for Engineering Data Sheet No. 34.

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withstand temperatures as great as 1650° F. Designed to permit baking, broiling, or barbecuing with the food in full view, the oven unit cover consists of two Pyrex brand glass hemispheres, one mounted inside the other. The larger dome is 28 inches in diameter; the smaller, 26 inches in diameter.

The two domes were sealed to a single ring gasket and mounted over the heating unit. An envelope of cool air between the domes keeps the outside glass cool, even when temperatures on the inside approach 500° F. A flick of a button sends the domes swinging under the unit to disappear completely, allowing unhindered access to the oven.

Radiant Glass Heating

Radiant glass heating, accomplished by passing electricity through an aluminum element fused into glass at high temperatures, is now practical and usable under varied climatic conditions. The heating panel is a plate of tempered glass 16″ x 24″ x ¼″ thick, into which is fused a continuous aluminum alloy grid which serves as a heating element.

The plate is backed by an aluminum reflector, and the assembled unit is mounted in the wall of a room. It may be used as a complete, or auxiliary, heating system. Each panel heats approximately 1000 cubic feet of space.

Glass Capacitors

Glass is being produced in a unique form, consisting of a thin, flexible continuous ribbon in widths from approximately ¼″ to 6″, and of uniform thickness from about 0.020″ to 0.0006″. These dimensions are not the limits obtainable, but represent sizes used in experimental work.

Flexibility results from its extreme thinness, and physical properties in general are comparable to the glass from which it is made. Ribbons have been made from widely different glass compositions, and with properties designed for specific applications. Greatest importance has been placed on dielectric properties. A single monolithic unit may be made in the usual manner of stacking capacitors. The capacitors can be operated at high temperatures, substantially unaffected by moisture; they possess high capacitance per unit volume. The electrodes are permanently sealed to the dielectric, and their properties are quite uniform. Owing to the thinness and uniformity of the ribbon, a capacitor of smaller physical size and weight is possible.

Glass Bead Manufacture

Improvements have been recorded in the manufacture of glass beads, or very small spherical balls, used in motion picture screens, reflecting signs, road markers, and highway surface markers. The improved method consists of rolling or tumbling glass particles which have been previously coated with finely divided carbon. The carbon particles are sufficient in amount to act as a fuel bed, as well as a separator for the glass particles, and thus on heating or igniting prevent the glass spheres from sticking. The beads are hardened by dropping in water. The procedure is said to provide a considerable improvement in the art of making glass beads.

Dental Daylight Lamp Mirror

Until recently, dentists have been confronted with the problem of matching colors under artificial light. With a mirrored lamp it is now possible to focus cool, shadowless, white light on a dental area.

The heart of this new lamp is a curved mirror, the special glass composition of which filters out excess red and yellow light rays from the shielded light bulb so as to reproduce daylight. The mirror also absorbs heat, and only cool light is reflected.

This kind of glass is only one of several special "daylight" glasses; for example, one type is used in the powerful lights necessary for making color motion pictures, while another filters light to produce the perfect daylight required for accurate industrial color matching.

(Additional new products will be discussed in the concluding portion of this article next month.)

ELECTRONICS INDUSTRY

(*Continued from page* 621)

electronics manufacturing. Of this total, nearly 100,000 are engineers; 500,000, production workers (assembly machining, etc); and about 110,000, executive and salaried employees.

Although electronic plants are located in every state of the Union (excluding Alaska and Hawaii) and in the District of Columbia, nearly 70 per cent of the total manufacturing employment is concentrated in New York, Pennsylvania, New Jersey, Massachusetts, Illinois, and California.

Total employment is not expected to increase this year (1959) as fast as output, owing to increased mechanization of processes, simplification of design, adoption of standard parts and construction and modernization of plants. Heavier emphasis on research and development in such areas as magnetics, molecular electronics and solid-state phenomena, plus the greater application of scientific principles to production has strengthened the demand for engineers, draftsmen and technicians.

FACTORY SALES OF ELECTRONIC EQUIPMENT BY SELECTED YEARS
1947-1958
(Add 000,000 dollars)

Year	Consumer Products	Replacement Parts, Tubes Semi-conductors	Industrial Products	Military Products	Total
1947	$ 810				$1,750
1950	1,500	$250	$ 350	$ 500	2,600
1951	1,400	350	450	1,300	3,500
1952	1,300	400	500	2,200	4,400
1953	1,400	500	600	2,500	5,000
1954	1,400	650	650	2,400	5,100
1955	1,500	750	750	2,500	5,500
1956	1,600	850	950	2,700	6,100
1957	1,700	900	1,300	3,900	7,800
1958	$1,600	$860	$1,380	$4,100	$7,940

(Because the electronics industry is so important to glass manufacturing, the author will review that industry in further detail next month.)

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3 HIGHLY VOLATILE—Gypsum releases large amounts of SO_2 and oxygen. Theoretically, it is 67% volatile.
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5 REASONABLE COST—Gypsum gives the maximum benefits required of a sulfate source at low cost.

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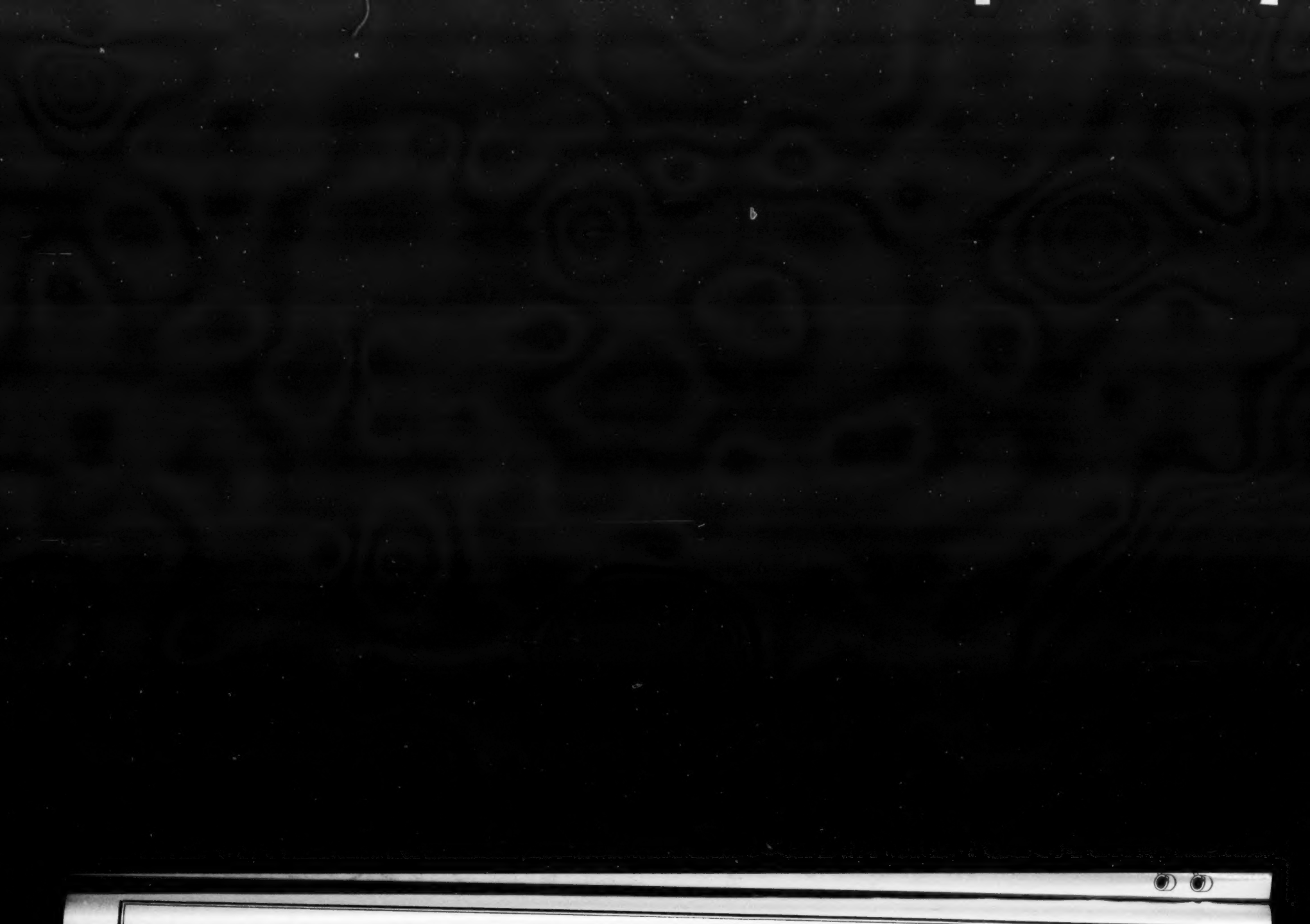
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